The Welding Engineer

Edited by L. B. Mackenzie

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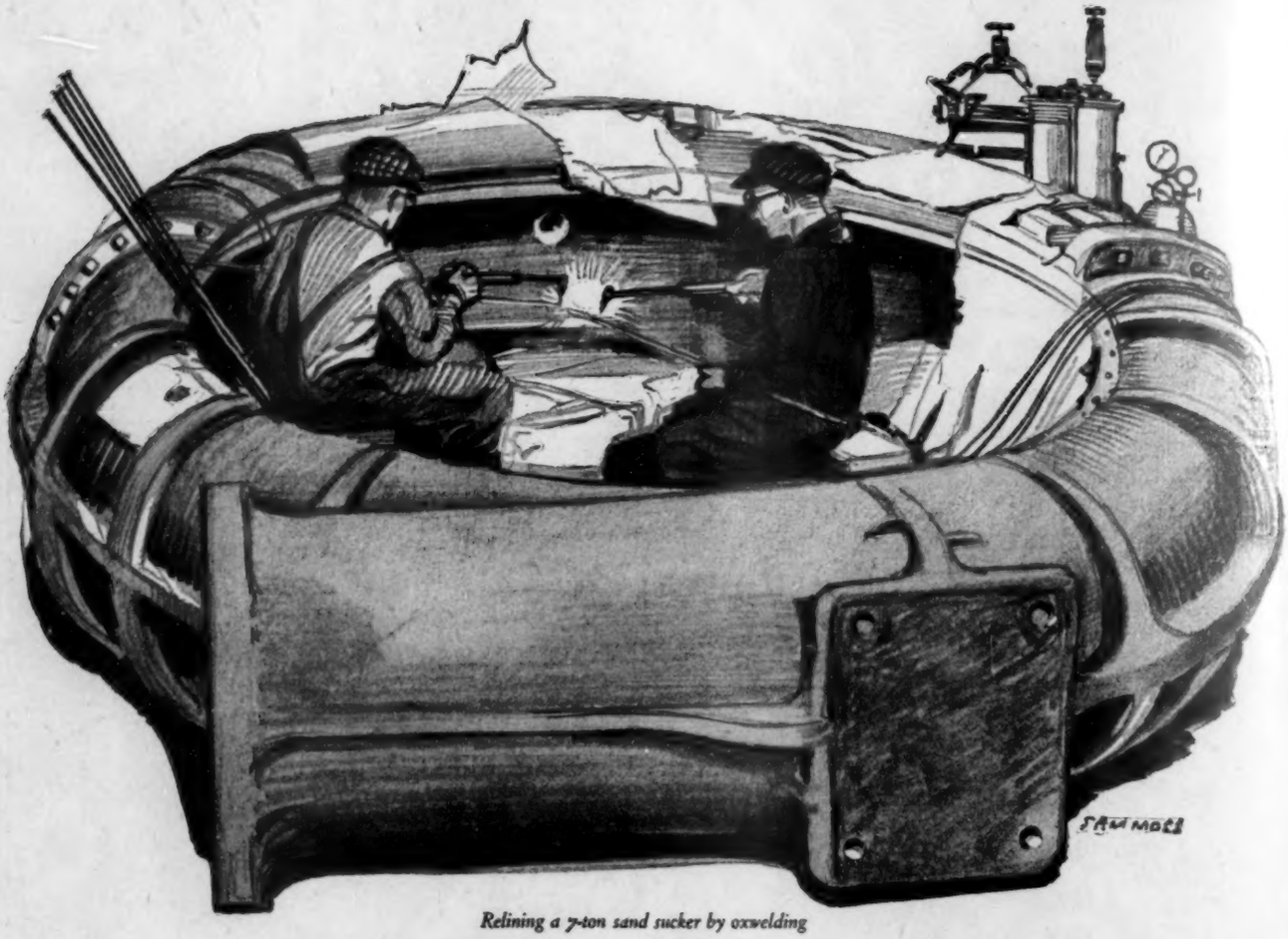

Relining a 7-ton sand sucker by oxwelding

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Readers of The Welding Engineer will find this index to contain the most accurate information obtainable relating to welding apparatus and supplies. The advertising section includes the principal manufacturers of the United States.

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Commercial Acetylene Supply Co.
Prest-O-Lite Co.

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The Imperial Brass Mfg. Co
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United States Welding Co.
Weldit Acetylene Co.

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Compressed Gas Corp.
Davis-Bournonville Co.
Hauck Mfg. Co.
Imperial Brass Mfg. Co.
International Oxygen Co.
K-G Welding & Cutting Co.
Smith's Inventions, Inc.
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Weldit Acetylene Co.

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Gas Products Association
International Oxygen Co.

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Universal Oxygen Co.

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Hauck Mfg. Co.
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Modern Engineering Co.
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Smith's Inventions, Inc.
Superior Oxy-Acetylene Machine Co.
Weldit Acetylene Co.

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Davis-Bournonville Co.
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The Imperial Brass Mfg. Co.
K-G Welding & Cutting Co.
Smith's Inventions, Inc.
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Superior Oxy-Acetylene Machine Co.

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Hauck Mfg. Co.
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Superior Oxy-Acetylene Machine Co
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United States Welding Co.
Weldit Acetylene Co.

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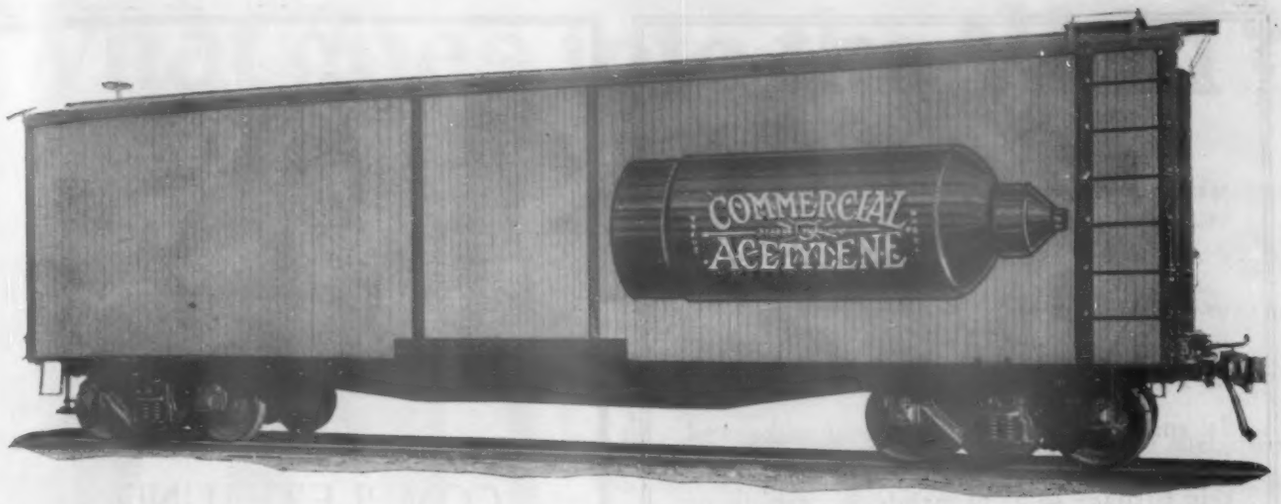

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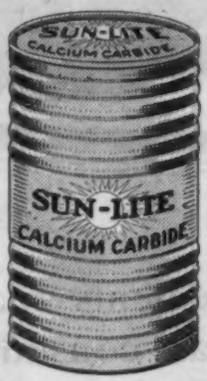

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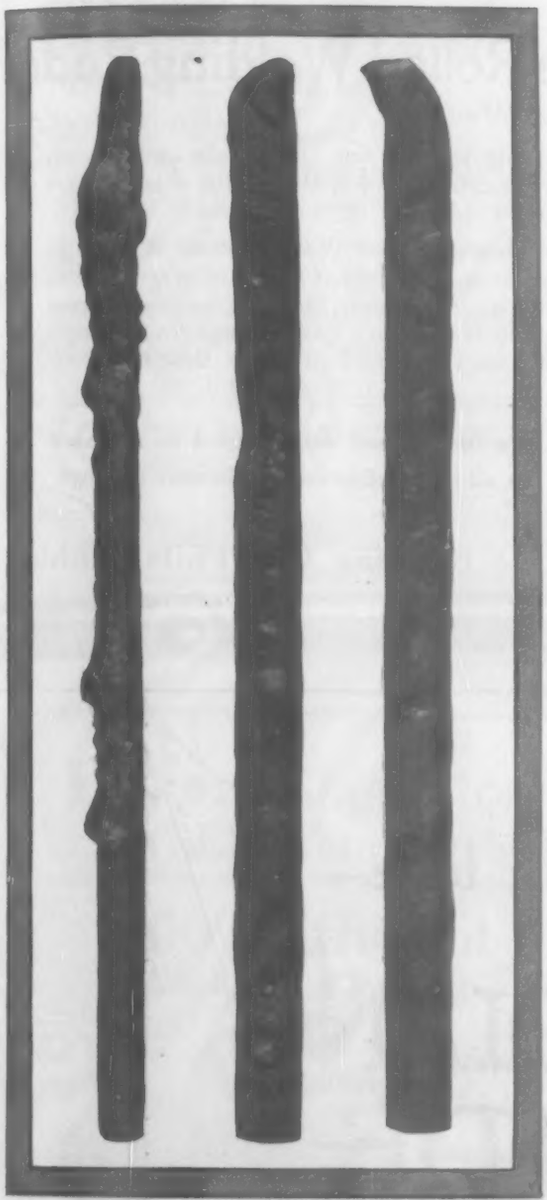

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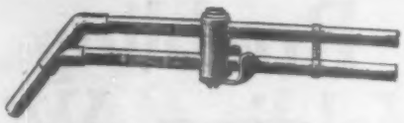

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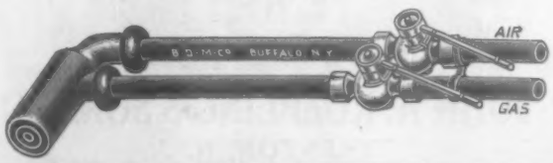

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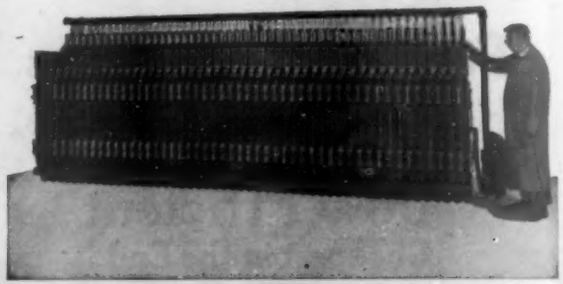

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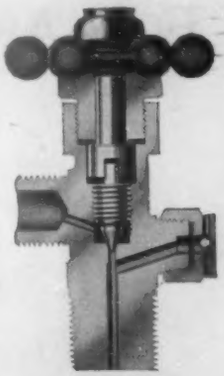

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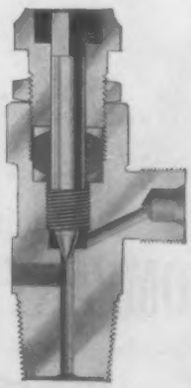

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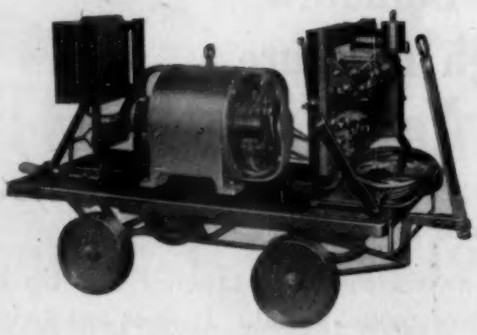

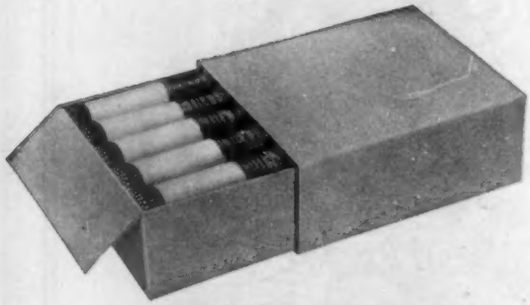

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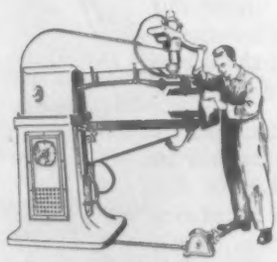

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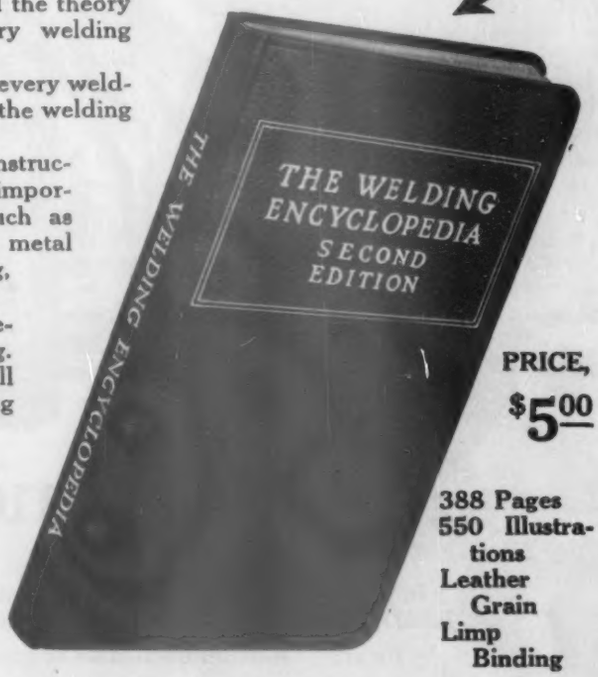

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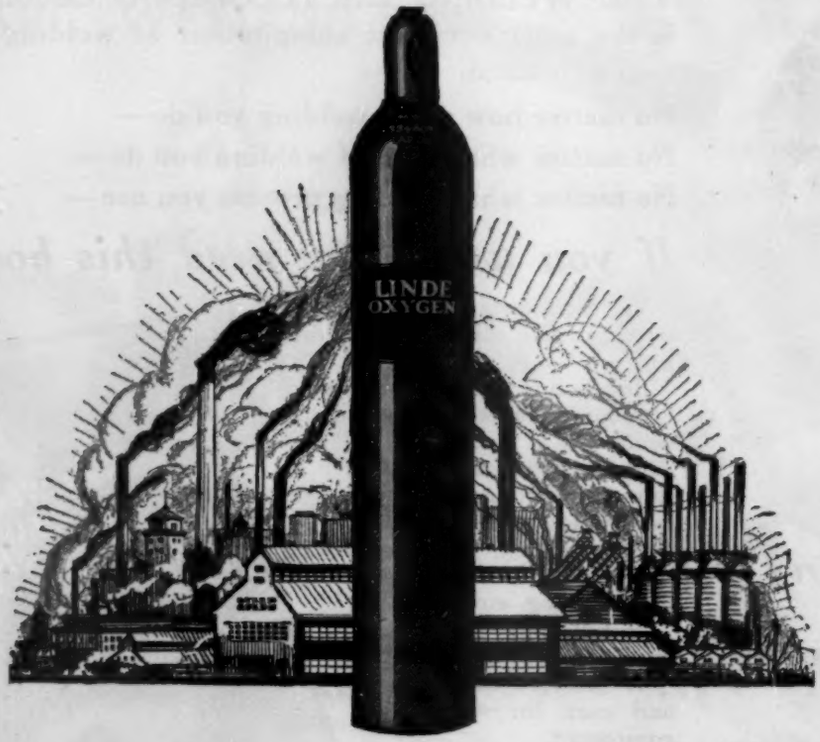

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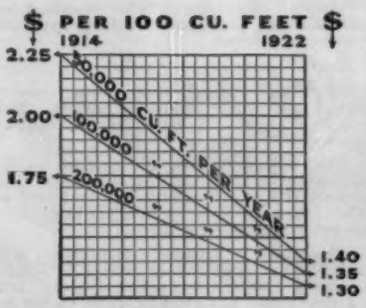

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DEFECTS IN GAS WELDS*

Lack of Penetration and Adhesion Are Most Common Sources of Trouble—Causes and Remedies Easily Found

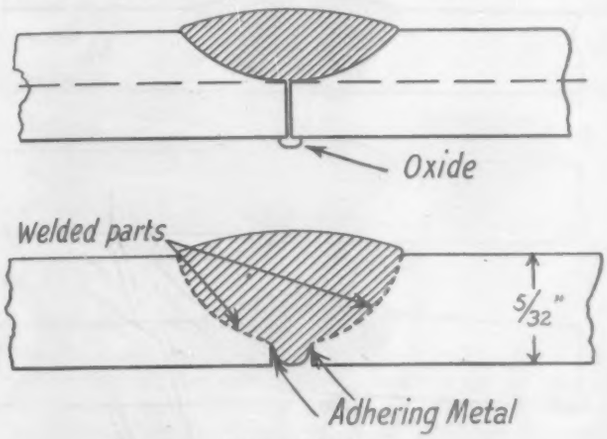
AMONG all of the defects in welds, the three principal ones, upon the importance of which it is not necessary to insist, are those whose names recur so often in the conversations of research men and practical welders:

1. Lack of penetration.
2. Fissures.
3. Adhesion.

All three of them are of prime importance, and there is truly a deplorable lack of technique, which is found as commonly among the great number of welders as among the industrial engineers. This general lack of knowledge has for many years permitted the application of improper methods of welding, and the result has been the production of the defects mentioned above.

We do not propose to give here once more the definitions of these defects which everyone of our readers knows, but rather, to look for their causes, determine their influences, and indicate the remedies.

The defects which we are starting to study, possess both a direct and relative importance. The direct importance is concerned with the effect they have according to the nature and the thickness of the metal, and from this point of view, it varies according to the operator. On the contrary, their relative importance is determined by the service which is required of the welded pieces, and we can easily understand that this or that defect, tolerable as it may be when it is only a question of joining pieces in which only a joint without resistance or strength is wanted, becomes extremely important under the same production conditions if the welded pieces must be submitted to serious stresses.



Figures 1 and 2.

These defects—lack of penetration, adhesion, and fissures are, however, easily avoided by using the right method. It is truly astonishing that in the domain of practice we find so few welders who have studied and acquired a method of execution which will give, for the ordinary run of work in the welding shop, results acceptable from the triple point of view of speed of execution, consumption of gas, and the strength of the joint.

Lack of Penetration

This is the first of these defects in the logical order in which they are presented, and it is its importance alone, according to the thickness of the metal welded, which differentiates it from fissures, which are nothing more than feeble indications of lack of penetration.

Lack of penetration is manifested in the first place on sheets of thickness up to $\frac{1}{16}$-in., which are welded by simply abutting the edges as shown in Figure 1. It is also found in welds made on thicker metal when the edges have simply been separated without beveling, or perhaps even just abutted.

More often in the second case than in the first, the lack of penetration is accompanied by a characteristic double adhesion of a quantity of metal which has been melted and then solidified between the two parallel faces of the edges of the plates which have not been heated to the point of fusion. The reverse side of the weld in this case usually shows very clearly the presence of the overlapping metal by observing the two lower angles of the edges of the plate which are rarely joined by the metal which has flowed between them. (Figure 2.) Consequently, they show open spaces which clearly characterize this defect. In this case a real weld is not made, and the joint is very easily broken by a bending test.

On the other hand, in very thin sheets, welded with or without tacking, or by bringing the edges close together, there is no open space to fill up and it is impossible to estimate the importance of the lack of penetration by simply looking at the reverse side. However, as soon as the welded portions solidify, a pronounced shrinking effect is felt all along the edges, and the pressure is strong enough to cause the passage of a certain quantity of oxide to the bottom of the weld, sticking there by capillary attraction, giving the deceptive appearance of a weld which has penetrated in good shape. Surface etching tests and deep etching will show this condition very clearly.

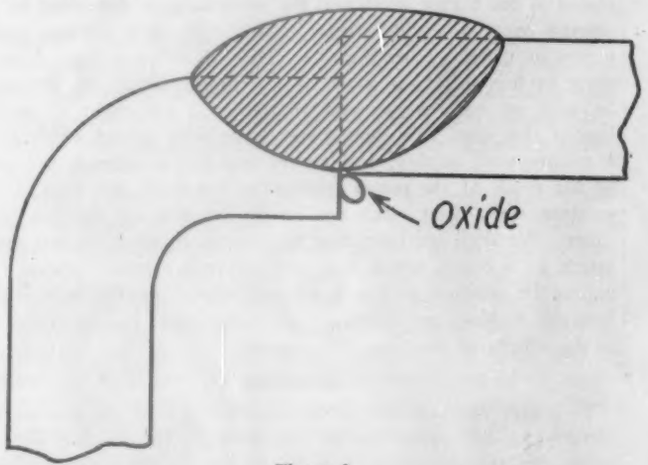


Figure 3.

Penetration of the puddle through the entire thickness of the metal is the first qualification which we should demand from a weld, and it is one of the first objectives which every welder should have. Lack of penetration in all the degrees in which it is found is the real cause of trouble in welding heavier sheet metal, that is, the thickness from $\frac{3}{32}$-in. to $\frac{1}{4}$-in. For the thinner sheets the contrary is true; that is, when welding very thin sheet metal, we have the opposite effect to fear which is, that an excess of heat will burn holes in the metal.

In welding sheet metal from $\frac{1}{8}$ to $\frac{1}{16}$-in. thick; that is, in making joints in which a great part of the metal of the sheet is melted, the adding material does not come in except to fill up the irregularities of fusion and to form a reinforcement. Good results in making these welds will depend largely on the welder's ability to judge them from a visual examination. This might be called possessing a sense of fusion. It is then almost altogether by means of this sense of fusion on the part of the welder that the right degree of penetration will be secured on

*By Marcel Piette in Revue de la Soudure Autogene.

sheets of this thickness. We have made the supposition that the sheets would not be beveled for these thicknesses because in the case of beveled sheets, the manipulation of the torch is very important, as we will see later.

As we have previously mentioned, examination of the reverse side of the weld can be deceptive and may not always make it possible to determine whether the weld has gone all the way through, at least when a clearly defined ridge or drops of

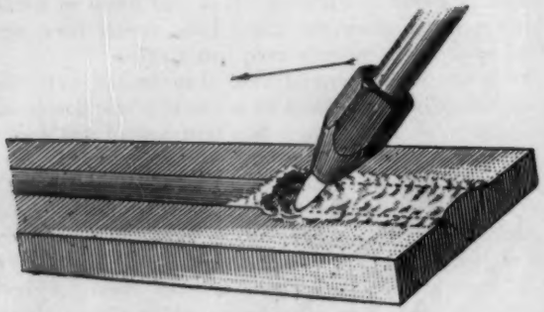


Figure 4.

metal from place to place are not present to prove that fusion has penetrated. Lack of penetration in the case where the two edges are at different levels during the execution of the weld is generally noticed at the base of the sheet which is placed at the higher level, and the penetration is decreased by an amount equal to the difference in height between the two thicknesses of metal. (See Fig. 3.) There is often a line of oxide more or less thick and more or less lumpy which can generally be seen on the reverse side of the weld and right along the line of the joint. An etching test made with iodine, which gives a picture very quickly, will permit making an estimate not only of the depth of the metal reached by the torch, but also of the existence of a very clear line at the junction of the two plain faces. We shall see later that this line is an alloy of iron oxide acting as a braze, which evidently offers a certain resistance to pulling in addition to the resistance offered by the part which is really welded, but which on the other hand has no resistance to the effects of bending, and torsion.

Adhesion

This very characteristic word describes one of the gravest defects which the welder has to contend with, for the best welders often experience failure, and this defect is to a large extent due to the operator. Incomplete fusion and adding melted metal on top of metal which is not melted are the principal causes of adhesion.

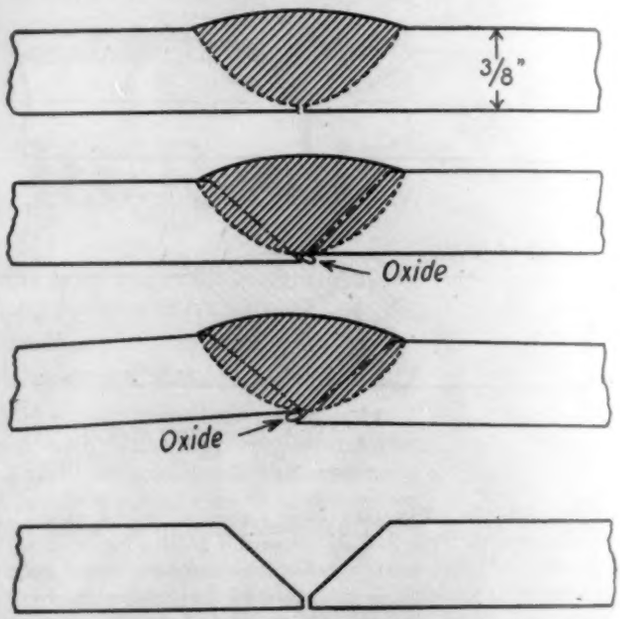
We do not hesitate to assert strongly that in welding sheets which have not been beveled, adhesion does not occur very often, while the defect is more readily obtained on sheets or plates which have been prepared by beveling. It is altogether a poor method of operation which makes the welder lose the benefit of this preparation in the course of the execution of the weld. When the sheets which are abutted together are only slightly separated, we may have, as we have seen, a lack of penetration, and a partial adhesion in the base of the weld, but on beveled sheets we have seen over the whole length of the line welded, and over $\frac{3}{10}$-in. of the thickness of the sheet, added metal which is not joined to the bases of the bevel, and showing the appearance of adhesion very closely under etching tests and bending tests.

The welder who works on sheets which are not beveled, must take care to get through the entire thickness of the metal. He knows that it is only by clever manipulation of the torch that he can do it, and that he has constantly at the left of his puddle, if he welds "forward," a sort of wall of metal to metal to melt, while on the other hand, the operator who welds on beveled edges sees before him no additional metal which he must melt, and he does not have to accomplish a progressive fusion from top to bottom, but simply has a space to fill up with molten metal and his weld progresses from the bottom to the top. We are speaking here, evidently, of metal of medium thickness; that is, from ¼-in. to ½-in. thick.

It appears then, that, beveling, which is done to make possible a weld of better quality, is at the same time a favorable condition for producing one of the gravest defects in welds.

If the lack of penetration in case of relatively thin sheets is due to an inexperienced eye and to a lack of the habit of penetration and familiarity with the appearance of the puddle under the flame, which we speak of as a lack of sense of fusion, adhesion is due especially, in addition to the causes set forth above, to poor manipulation of the torch, which is to say, to a bad method of welding.

In fact, adhesion on the face of the bevel is principally due to the fact that a certain quantity of molten metal is pushed forward in advance of the puddle and solidifies very quickly. Figure 4 illustrates the appearance of the weld under these conditions. This flow of molten metal is due to the impulse given by the flame as well as to the fact that the torch has been too much inclined. It will be seen that the molten metal is pushed ahead violently and fills up more or less of the space in the bevel. At this moment there is no fusion with the edges as the molten metal reaches them, and a defective weld is the result. Often on account of the very high temperature of the metal adjacent to the melted zone, a little stream of oxide



Figures 5, 6, 7 and 8.

is produced as soon as this point of fusion is passed, and it then forms a line of oxide alloy which we may call a "white adhesion" or an "oxide braze."

The welder often has a tendency to consider this metal which remains at a high temperature as joined to the sheets, and is satisfied to finish his weld by adding new metal which will be welded to the upper part of the sheets. The result of this procedure is adhesion in the weld.

In welding by successive pools in which a certain portion of the length of the bevel is first melted over its entire width, a method used for the heavier sections, the chances of lateral adhesion are greatly diminished, but we can find adhesion in the direction of the width of the pool. It is also found at the junction of two successive pools in a vertical sense, the zone of adhesion usually being located in the lower part of the weld.

If we examine this "white adhesion," we find that it forms a braze consisting of an oxide alloy, by reason of the fact that the fusion point of the oxide has been passed. Microscopic

examination will show this very clearly, and a hardness test shows that the hardness of this brazed zone is about equal to that of the adjacent metal.

As we have already stated, this braze has a certain resistance to pulling stress, and we have seen portions of welds or even welds which were entirely adhesion, show a considerable resistance on account of their favorable position with reference to the direction of the stresses. This is not true when the piece is subjected to a shearing stress or shock.

It must be remembered that a good many welders do know that the melted metal which has solidified, and which they see piling up in the pool, is not always joined to the edges. This leads them to melt the metal a second time so as to be able to reach the faces of the bevel. Then they are working under exactly the same conditions as in welding where the edges are not beveled but simply brought together. It is easy to see that the necessity for remelting a veritable wall of metal, deprives the welder of the advantages which this beveling was to have given him; namely, the facility of penetration and joining of the metal and a greater speed of execution.

In such case as this, we find the following alternative:—Either the molten metal which has been pushed ahead by flame and has solidified before the edges have been melted, will remain such as it is during the execution of the weld, in which

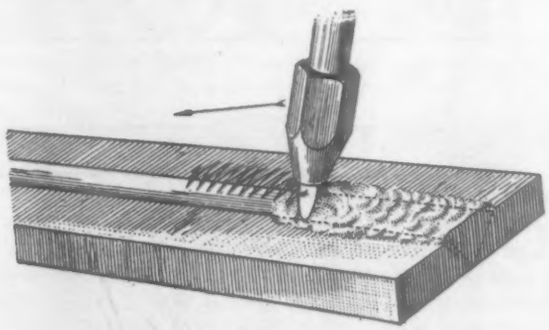


Figure 9.

case the only metal really joined to the sheets by fusion will be a small portion of the surface hardly reaching ½ or ⅓ of the width of the weld; or in the second case, the welder, knowing the existence of this defect, will want to overcome it and will have to melt again this solidified mass, so as to be able to reach the faces of the bevels which it covers. It is clear that he operates at this moment under the same conditions as if he were welding without beveling, since he is melting again the metal which is covering up the bevel, and therefore, he loses all the benefits of beveling.

Fissures

When the welder examines the reverse side of a weld of medium thickness, immediately after he has finished it, he generally finds occasion to be satisfied with his work, and to believe that he has secured perfect penetration; in fact, the edges of the sheet or the lips of the bevel have been drawn together by the contraction of the molten puddle and a thin thread of oxide appearing to be melted metal, or a few granulations, are visible all along the line of the edges which have been drawn together.

However perfect a weld may appear, the accomplishment of a weld without a fissure in it is extremely difficult, and lack of penetration, no matter how feeble it may be, is found in welding much more frequently than adhesion.

We do not hesitate to state that all welds which do not show a tiny ridge or a few granulations of melted oxide are sure to contain a fissure. It is caused by insufficient penetration which is a consequence of the fear of making a hole, which many welders have. A hole to close up, or a cavity to fill in the line of the weld, evidently decreases the welding speed, and detracts from the regular appearance of the weld, so the operators usually are inclined to be overprudent in this respect.

A fissure then, is a lack of penetration, very small it is true, and perhaps not reaching a tenth of the thickness for plates from ¼-in. to ½-in. in thickness in the case of plates perfectly aligned on the same plane. (Figure 5.)

But such a fissure may come from other causes. In the first place, from the overlapping of the beveled edges which are drawn together under the contraction effect of the weld, and as a consequence of a poor penetration of the pieces. The opening made by the bevel is decreased at the same time, and the weld, even though it accomplishes the fusion of the bottom of the bevel, is not deep enough, and since it cannot affect the entire thickness of the metal, a slight fissure is the result. (Figure 7.)

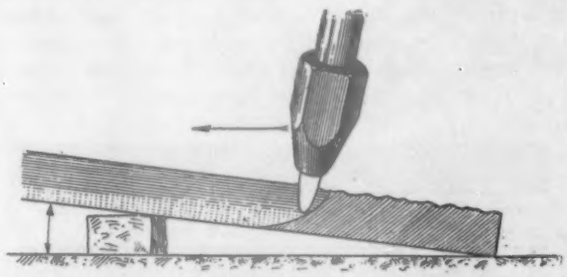


Figure 10.

Another cause of fissures, which is still more frequent, is the changing in levels of the plates, especially when they are not beveled. Here again the oxide, which accumulates in a thin line, causes a false appearance of thorough penetration. But this error may be guarded against as has been explained above. (Figure 6.)

Another cause of fissures in welding beveled plates which should be noted at this time, is the incomplete bevel; that is, a bevel which although it is made at the correct angle, does not extend through the full thickness of the plate, so that there remain, at the bottom of the puddle, two parallel faces, constituting a certain thickness of metal which must be melted in addition to the faces of the bevels. (Figure 8.) This sort of preparation does provide a certain protection against a possibility of the puddle falling through, which happens sometimes in the case of bevels made at sharp angles, whether welding forward or backward, but at the same time, is one cause of a dangerous fissure. Let us add that welds whose reverse side presents the appearance of a perfectly clear line, can immediately be put into the category of weld having a lack of penetration which may reach 10 to 15 per cent of the thickness of the plate. The same thing is true of welds showing on their reverse side a thread of oxide retained during the welding by capillarity, as we have pointed out previously when speaking of lack of penetration on thin and medium sheets. If this oxide is destroyed by etching or chipped off, lack of penetration in the weld will be evident. The oxide then acts as a braze as we have said when speaking of adhesion.

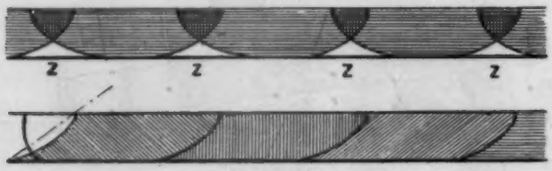
In practice, fissues are counterbalanced from the point of view of lack of resistance to pulling by reinforcement which we can give to the line of the weld.

What is the defect of the fissure and why do we qualify it as dangerous? This defect, which is not very important in a certain number of ordinary jobs, becomes much more important when it is a question of assembling by welding pieces which are subjected to alternate stresses and shearing stresses, such as liquid containers or pressure gas container, boilers, etc.

A fissure, no matter how small it may be, means an interruption of the joining of the fibers of the metal at the surface where it is found. In case of alternate or vibratory stresses, the fissure acts the same as a nick made in a bar when testing for fragility. Furthermore, as a simple shock shows very clearly whether tests are performed by using a falling weight or by

bending the test piece in a vise; it is always found that there is a very clean break through the middle of the weld.

The study of some welding failures, past and present, has shown the importance of fissures, and especially the lack of penetration in sheets in the neighborhood of ¼-inch thickness. Some of them, of course, are due to poor execution, however, we recently examined one failure on a ½-inch plate, and in this case it was perfectly evident that the weld had been done by an expert. There was a very small fissure but the weld had been reinforced to a depth greatly exceeding the depth of the fissure. The failure, by the way, was caused by an explosion due to a chemical reaction which produced a pressure far in excess of the working pressure originally demanded of the container. When an examination was made, the blame for the break was not laid on the weld itself, but some very important observations were made on the effect of these fissures. The rupture occurred through the middle of the weld, but in the zones where perfect penetration had been secured as indicated by the presence of drops of metal on the reverse side, the line of the



Figures 11 and 12.

break stopped and made a detour around this drop of metal. Test pieces were then welded, purposely leaving some portions without penetration and taking care to secure extra penetration in other portions. After welding, the test pieces were submitted to bending tests which show clearly that the breaks begin in the parts where penetration is incomplete and are turned aside when they reach the zones which have been thoroughly fused.

Remedies

Now that we have explained the three principal defects in welds on iron and steel, let us see what the remedies for them can be.

These remedies exist and they must be carefully explained because they are at the disposal of everybody. They will permit the making of welds which will pass all tests and will allow the welder to work with complete confidence.

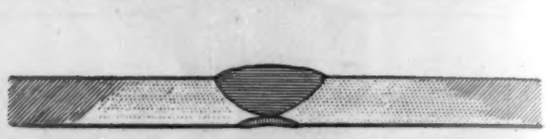
We have seen that in making welds on sheets up to ⅛-inch thickness, lack of penetration is a frequent defect and it is caused partly by the failure of the welder to realize how deeply the metal must be melted. There is no other remedy for this except to teach the welder by drawing his attention to the undesirable consequences of lack of penetration and of fissures in all welded joints which will have to stand not only pulling stresses, but also bending and shearing stresses. This is not the place for giving precise instructions concerning the method of holding the torch and the power of the torch, the speed of welding, etc., the point to be made here is that the welder must constantly make a check on the reverse side of his weld and make sure that he is melting all the way through.

It is not enough, as we have seen, to find a ridge or a thread of oxide on the reverse side of the weld. A ridge of molten metal, well joined to the base of the sheets is the only indication of a good weld. It is not expected that a perfectly regular and continuous ridge can be secured, because this would demand a remarkable degree of cleverness, but the penetration ought to be made evident by successive drops, fairly close together, which will serve to limit the consequences of lack of penetration, as we will see later when speaking of fissures.

As far as adhesion is concerned, only one rational method of execution can serve to overcome this defect. We have seen how the inclination of the torch in the execution of welds on beveled plates leads to a projection in advance of the puddle of a considerable quantity of melted metal which solidifies immediately without being joined to the face of the bevel. (Figure 4.) We teach our welders when making continuous welds, to hold the torch as nearly vertical as possible to give it very little transverse movement, and contrary to the method used for thicknesses below ¼ inch give it no longitudinal or elliptical movement. It is clearly desirable to work, whenever possible, on inclined plates, as shown in Figure 9.

A nearly vertical position of the torch permits taking advantage of the greater part of the heat in the flame in elliptical or longitudinal movements in the torch and will result in a displacement of the melted metal which must be avoided in order to prevent adhesion; the projection of melted metal can be diminished considerably by an inclination of the plate as shown in Figure 10. The adding material of the right diameter is brought in contact with the bevel situated behind the torch, passing alternately on each side of the flame.

Briefly, all these conditions together, allow us to restrict the amount of metal which may work ahead of the puddle to an insignificant quantity. Then we can obtain a free and normal fusion of the edges and a perfect union with the adding material, at the same time controlling the degree of penetration and a greater speed of execution, which is always an important factor.



Figures 13 and 14.

It is this method of continuous forward welding which is the nearest approach to backward welding, a method which we consider the most rational, and which has been explained in detail in previous discussions.

In welding by successive puddles we have seen that lateral adhesion is less frequent than in the method of continuous welding; however, adhesion can be produced in the lower part of the junction of two consecutive puddles. (Figure 11.) We can avoid this defect by welding on an incline, so that the puddles will have the appearance shown in Figure 12. In this manner, the union of two consecutive puddles is made without adhesion at the bottom of the bevel.

There are also ways to guard against the consequences of fissures, giving to a weld the maximum strength, and to reinforce it, thus disposing of such secondary defects as thin places, rough spots on the sides of the puddle, etc., at one time. These methods are a deliberate formation of a ridge or drop of metal on the accomplished with the torch.

Welders are generally divided between a desire to get thorough penetration, and a desire to make good speed. Since thorough penetration means that the speed of welding will be perceptively diminished, the welder adopts a middle course, especially when he is working by the piece, and welds almost through, leaving only about $\frac{2}{64}$ of an inch not welded on the lower side; in other words, a fissure.

Now, it should be brought to the attention of workmen that the drops of melted metal well joined to the lower surface of the plate, constitute a very strong reinforcement to the joint, and are veritable welded rivets.

The influence of these drops is absolutely remarkable. Always, without exception, when breaks have occurred in welded containers, the observations made have been identical. The fissure causes a separation through the middle of the weld, but every welded drop turns aside the break toward the middle of the plate or even stops it completely.

Numerous tests have been made to make this point more clear and our conclusion is that all failures caused by fissures can be completely avoided by the presence of drops on the reverse side, or better yet, by a continuous ridge.

We have also recommended the repair of the reverse side of the weld. We do not mean by this exactly the same thing as the welding on the double V design. We are speaking rather of the fusion of the line of weld on the reverse side. (Figure 13.)

This can be done with the same torch, or better, with a less powerful torch, but there is another method of repairing the reverse side of the weld which was recommended some years ago by an Italian engineer; a method which we have tried, and which gives very good results wherever it is possible to apply it. That is, the fusion and joining of the edges of the plate on the reverse side of the weld by a second welder, equipped with a less powerful torch and working from underneath while the first welder makes his weld normally. The repair operation is then made in such a way as to use a great part of the heat present in the vicinity of the weld, and a considerable economy in gas is affected.*

(**Note:—The description of this process sounds very much like the procedure which is commonly known as "wash welding," but should not be confused with it. Wash welding is usually done with the view to improving the appearance of the bottom of the weld rather than improving its strength. What the author wishes to recommend is that the welder should secure absolutely complete penetration. Figure* 13 *shows the result. The result of wash welding is shown in Figure* 14, *and the author comments on the undesirable features of such a procedure.—Editor.*)

We have made some experiments with this method of welding on plates about ⅜ inch thick. The method of operation which seems to be the best is as follows:

The second torch should melt the metal about 1 inch behind the place where the puddle is, and the power of the second torch is about one-fourth that normally used for the total thickness of the plate, and it does not appear necessary to add filling metal. The execution of a weld of this kind evidently necessitates considerable cleverness on the part of the man who is welding underneath, but the process can be considered as rational and economical as far as the gas consumption is concerned, when we take into account that the maximum resistance and safety are realized in the completed joint. Breaking tests on specimens have shown the practicability of the process permitting bending, by hammering or dropping weights, to very sharp angles. We should also take into account here that this kind of a test indicates the fragility of the piece, and our experience has been that the test pieces were very strong in this respect without having received any heat treatment or mechanical treatment.

It should be noted, however, that it is quite possible in the application of this method, to have incomplete fusion of the lower surface, which will leave a fissure. In this case, the fissure will exist on the inside, and we have been able to determine that the method loses its entire value in this case, and that the break of a joint is produced with all the characteristics of a break caused by a fissure which had not been touched.

Conclusions

We have then shown the methods of remedying certain important defects which are present in poorly executed welds. Are these remedies capable of application commercially in all cases?

We have already shown that it is necessary to attach more and more importance to the above mentioned defects when we are dealing with jobs that the cost of the work is less important than the matter of having a joint which will be perfectly safe under all the surface tests which it will have to stand. Therefore, the welder has the responsibility of taking advantage of every possible method which will give the maximum guarantee of security.

However, from the point of view of refinishing the work, where it is necessary to re-roll or hammer into various shapes, whether the pieces show a small flange on the reverse side of the weld, or simply drops of metal, it is certain that these ought to be removed by a portable grinder in preference to a chisel in order to avoid the formation of tool marks or sharp corners where the chips have been taken out. We have been able to show, after comparative tests, that after complete grinding of the welded drops on test pieces, the resistance offered by the weld to break, was still very strong, although a little less than the resistance before grinding, and that the metal joined to the plate at the location of the drops which have been taken away by the grinder, served to stop the weld from breaking through the middle just as the drops had served this purpose. It is preferable then, in important work, to cause the formation of a ridge or of drops before putting the weld in service, rather than to economize by not providing this reinforcement, thus leaving the joint exposed to the dangers created by a fissure.

We must take into account the case of small jobs in the sheet metal shop, such as containers of small content, in which the dimensions or the forms would not permit either welding from underneath or dressing off the inside of the weld. The skill of the welder himself, and the inconvenience of the work are also factors entering into account here.

However, there exists a great quantity of constructions in which there might well be applied, without great difficulty, the methods we have just pointed out for increasing the strength of welds.

It is on this account that it has seemed worth while to us to bring to light the principles and methods which permit of obtaining best welds, and consequently, to increase confidence which everybody ought to have in the process of joining metals by welding, as applied to the ordinary jobs found in the sheet metal shop.

A HINT FOR OIL FIELD WELDERS

By J. H. Ady

In July, 1919, I was called upon to weld an extra 5-foot extension to an oil well drilling stem. The work was done for a well drilling contractor of Leetonia, Ohio. The extra length was called for because of the necessity for additional weight.

The first step in the job was to cut off the rope socket end with the cutting torch, then bevel the ends of the rope socket end with a cutting torch, then bevel the end of the rope socket to a chisel edge, and bevel each end of the extension in the same way. In all there were four ends which had to be beveled to 90 degrees with a cutting torch.

The next step was to line up the stem and the extension accurately on V-blocks. Then we proceeded to build a pre-heating furnace around the parts to be welded so as to save gas and get a weld of a better quality. The ends were pre-heated to almost a white heat; then the welding was started by fusing the ends together at the bottom of the V. The beveled edges were melted down to fill in, and then the filler rod was used to fill up the gap to a depth about equal to one-fourth the diameter of the stem. We then turned the stem over and followed the same procedure on the other side. This practice of welding a small portion, then turning to the other side was carried out in making both the necessary joints. The result was that we had no trouble at all with warping. This work was done several years ago, and the drill is still in service. Thousands of feet of holes have been drilled with it since these welds were made.

CALIFORNIA WELDER USES BOOKLET TO ADVERTISE

Brown Brothers Welding Company, of San Francisco, Cal., have a large two-story building full of equipment for doing thermit, electric and gas welding. They have just completed printing of a very complete booklet which illustrates their facilities for doing work inside the shop and outside the shop, and also serves to show the variety of repairs that are possible by these various processes. Some of the especially interesting illustrations in the book show a portable electric welding unit, an interior view illustrating their 8-ton traveling crane, a stationary 4-operator electric welding unit, a battery of 25 portable oxy-acetylene units, and a series of jobs on heavy castings, boilers and tanks.

WELDED RAIL JOINTS*

Wide Differences in Opinions and Practices Indicate Need for Further Research on Rail Joint Problems

By E. M. T. Ryder†

Introduction

THE subject Welded Rail Joints is by no means a new one, but it has certain aspects which we usually associate with new problems, namely the features of novelty and uncertainty.

As variety is still the spice of life, Way Engineers find the subject fascinating in itself aside from the promise it gives of substantially solving one of our most serious track problems.

It also carries a lurking danger in the allurement it offers for experimentation on a large scale, with the ultimate expense unknown.

In dealing with welded rail joints, some of us are inevitably reminded of the "little girl who had a little curl, etc.," for there is no doubt that "when a welded joint is good, it is very, very good, but when it is bad, it is horrid."

Some Engineers are even yet unconvinced of the wisdom of "burning their ships behind them" and trusting themselves to build new track, or rebuild old, with welded joints and without the comfortable feeling that there are at least a half dozen good one-inch bolts in each joint trying to keep some evil agency from making them work "loose."

Let us assume that there is some truth in the idea that we are lost in the welded rail joint woods. What should we do?

In such circumstances there are three things to consider:

First: Where did we come from?

Second: Where are we now?

Third: Where should we go?

History

Answering the first question it can be truthfully said that we have come a long way, farther perhaps than we realize. Welded joints have been in the field since the beginning of the electric railway industry.

Falk Cast Weld Joints were in use before the horse cars disappeared. Lorain Bar Welds were being tried out nearly thirty years ago.

Perhaps a brief glance at the development of the principal types of joints may be interesting.

Cast Welds

Joints of this type were installed in 1890 in Brooklyn on old rail and in 1894 in St. Louis on new rail. An old Falk Company catalogue shows that they installed cast weld joints in rail from 9 in. high, down to 3 in., (the latter in Oakland, California, in 1896) and that 500,000 joints were installed in five years.

Resistance Welds

To the Lorain Steel Company and its predecessor, the Johnson Company, is due the credit of making a commercial success of this type of joint, the pioneer work having been done in 1894.

The bar weld which was their standard for many years, consisted in welding a flat bar on each side of the web of the rails to be joined, the actual welds being located at the ends and in the center of the bar.

This process has been improved within the last half dozen years by the addition of a chock block welded under the heads of the rails directly at the joint and also welded to the webs of the rails and to the main welding bar. Some 800,000 bar welds have been installed to date.

The Lorain Steel Company is now also installing a "Butt" weld under the Jacobs patents, upwards of a thousand of these joints having been put in during the past year.

The process welds the entire cross-section of the rail ends, leaving a finished joint hardly differing from the rail itself in size by more than the thickness of a lead pencil.

Seam Welds

When trolley lines were first built, the use of a sewing machine to make rail joints would hardly have been regarded less visionary than to make a "seam" between rail and joint plate by using an electric current and a carbon or steel pencil, but the magic of the electric arc is now responsible for the making of seam welds by thousands on electric railway properties all over the country. Some welds were first developed on a commercial scale in Germany and were introduced into this country in 1914 by the Atlantic Welding Company. However, four years before that date, joints designed by Mr. C. F. Gailor had been installed in track on Main St., Hartford, Conn., using acetylene gas to make the welds, these joints lasting in sound condition until the track was reconstructed in 1918.

The Atlantic Welding Company in their first work in New York City used double refined iron plates, Swedish iron rods and a semi-automatic control for the electrode holders obtaining current from imported motor generator sets weighing five tons. Changes were gradually made to the methods now in use, using steel plates and rods and hand control for the electrodes, with generating apparatus light enough to be moved about by two or three men. The resistance method of stepping down trolley voltage is also in use and both metallic and carbon electrodes have their advocates.

In describing present conditions, one may use various terms according to his convictions, or his nerve. If not pessimistic enough to say chaotic or embryonic, he might be contented with experimental or developmental.

An impartial observer could hardly say that we have reached "normalcy."

Thermit Welds

Now-a-days chemistry is so interwoven with all our actions that we do not stop to think where that science ends and others begin.

Making a rail joint in a chemist's test tube might be said to have became an actuality in the case of the Thermit joints.

Thermit joints like seam welded joints were developed in Germany, reaching commercial proportions about 1902. In these joints the rail ends were butted together, heated by the Thermit metal and then forced togther by clamps. The only present modification in European practice consists in using a copper coated steel plate between rail heads which is thought to increase weldability.

Thermit welding was introduced into the United States in 1904 and has had three principal stages of development.

The method at first used gave a weld of the base and web of the rail only.

In the second method, the rails were separated, the Thermit casting filling the entire space and forming part of the running surface of the rail. The present method introduced ten years ago is based on inserting a head shim of rail steel to form the running surface, the Thermit steel welding the rest of the section, including in girder rails the lip and the outside of the head. Recent improvements have cut down

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*Paper presented at joint session of A. W. S. and American Electric Railway Engineering Association, Chicago, Oct. 4, 1922.

†Way Engineer, Third Avenue Railway System New York City. Vice-Chairman, Welded Rail Joint Committee.

the amount of Thermit metal and of manual labor required while at the same time increasing the reliability of the process.

Present Conditions

Our second question in the welded rail joint woods is: Where are we now? Let us answer this question by asking some others. Have we taken our bearings carefully? Are we on the right track? Do we know how to make each type of rail joint the very best way? Are all the metallurgical problems settled? Can we control the processes so as to always get good joints and never bad ones? Must we not admit that we are compelled to answer many of these questions in the negative?

Progress Report Number One of the Committee on Welded Rail Joints throws some light on these questions.

Looking through the replies for Cast Iron Welds, we find the following (the classification numbers being used for reference purposes):

112.1 Weight of Joint Castings:

Smith: 100 lbs., Wilson: 170 lbs., Cram: 200 lbs., Kerwin: 235 lbs.

Agreement on such a fundamental as the size of the casting is certainly not complete.

180.1 When do cast welds fail?

Cram: "Failures are principally due to *slips*."

Kerwin: "About 15 per cent of joints show breakage of *head of rail* over weld after twelve or more years of service."

Smith: "The greatest number of failures are in the *casting*."

Wilson: "Most failures occur by *rail splitting* at top of web directly under the head."

The doctors do not even agree as to the cause of the demise.

Picking out one item in the report for Resistance Welds, it is amusing to note the answers to the query 232.12: Use of expansion rails in closed track.

George, "No." Punderford: "Yes." Kleinschmidt: "No." Steward: "Yes."

For electric seam welds there were more replies to the inquiry schedules than for any other type of joint and there was more variation in practice and in opinion.

The practice of some companies is to weld seams for the full length of the plates; on the other hand, some companies do not weld seams all the way to the ends and some do not weld seams at the center of the plates.

Beveling the top of the plates is practiced by many, but considered unnecessary by others.

Base plates are not generally used, but have some enthusiastic advocates.

As to using inserts or shims, some use them freely, some not at all. Many allow a single shim as an unavoidable evil; while one reply advises using more than one and one man prefers to melt down his rail ends and build them up again.

In the matter of heat treatment, a few companies preheat the joints before welding and one post heats, but the majority do neither.

It is only fair to the Way Engineers to say that the manufacturers of joint welding equipment are themselves not in a position to give authoritative information on a great many of the moot points in the welding art.

The fact is that for all types of rail joints, our knowledge of the physical, chemical and metallurgical problems involved is altogether inadequate.

From the Engineering point of view we do not know either the loads applied to the structure or its powers of resistance.

With any of the different types, we can make joints which look good when they are new. What will be the effect of rail wear, of the hammer blows of traffic, of temperature strains, or repeated bending, of corrosion, of time itself?

What we want to know is how to make joints that will last as long as the rail.

We do not know that now.

Future Development

This brings us to our third question: Where should we go? Where, but to Science and Cooperation, two of the most powerful factors in the world's progress today! Many of us are attacking these problems independently, which inevitably means duplication of effort and probably means very slow and uneven progress.

Scientific study of such complicated problems as exist in the production of welded rail joints can be undertaken to advantage only under expert direction and with adequate resources.

Both of these requirements seem in a fair way to be met by the organization of the Committee on Welded Rail Joints.

Its membership comprises Experts of the U. S. Bureau of Standards, Purdue University, and other technical laboratories, together with Representatives of Rail and Equipment Manufacturers and Way Engineers from many of our principal Electric Railway Systems.

The committee should have the backing of the entire Electric Railway Industry.

HELPFUL SUGGESTIONS AND POINTS TO BE OBSERVED IN THERMIT WELDING

The following suggestions and recommendations not previously published in instruction books on Thermit welding will be of interest to welders engaged in repairs to heavy sections made by this method.

1. Making Pattern Wax Plastic:

In previously published directions for making plastic the yellow pattern wax to be applied between sections to be joined by means of Thermit welding, it was recommended that the wax should be placed in a pan and warmed until it became plastic, or else melted entirely and allowed to cool until it became plastic. Another way of making wax plastic, which has been found very satisfactory, is to pour the melted wax in a small stream into cold water. Very shortly thereafter, it can be removed with the hands and the water squeezed out. It then will be found sufficiently plastic for use.

2. Connecting Top of Pouring Gate and Riser:

After hollowing out a basin in the top of a rammed up mold, a channel or trough should be cut in the top surface of the mold, connecting the top of the pouring gate and the top of the riser. This will cause the first slag, overflowing on top of the mold, to quickly run across to the riser and thus while the metal is very liquid, equalize the pressure on the pouring gate and the riser.

3. Use Liquid Fuel Not Gas for Preheating in Thermit Welding:

The use of gas for preheating in Thermit welding should be discouraged because in order to properly preheat a section in a mold without badly burning away the preheating gate, it is necessary to use vaporized liquid fuel (gasoline or kerosene) which can be blown into the mold at such a velocity that the location of the flame can be varied at will. Thus by increasing the velocity at the end of the burner pipe the lower part of the frame can acually be cooled down and the upper part heated. The frame at all times can be so regulated that the heating gate will be dried out but will not be burned. This is not the case with any gaseous fuel whether it be natural gas or illumating gas, etc., and in all such cases the flame will either start at the end of the burner pipe, or will be blown completely out. This mass of flame passing continually through the restricted heating gate during the entire preheating operation is bound to do considerable harm, and in all cases the lower part of the mold and the section being preheated will be at considerably higher temperature than the upper parts.

4. Character Flame in Preheating:

Too rich a flame during the early part of preheating may not be harmful, but especially toward the end care should be taken that no excess oil be used so that the lean flame will tend to burn out from the molding material any oil which may have penetrated during the early part of the preheating.

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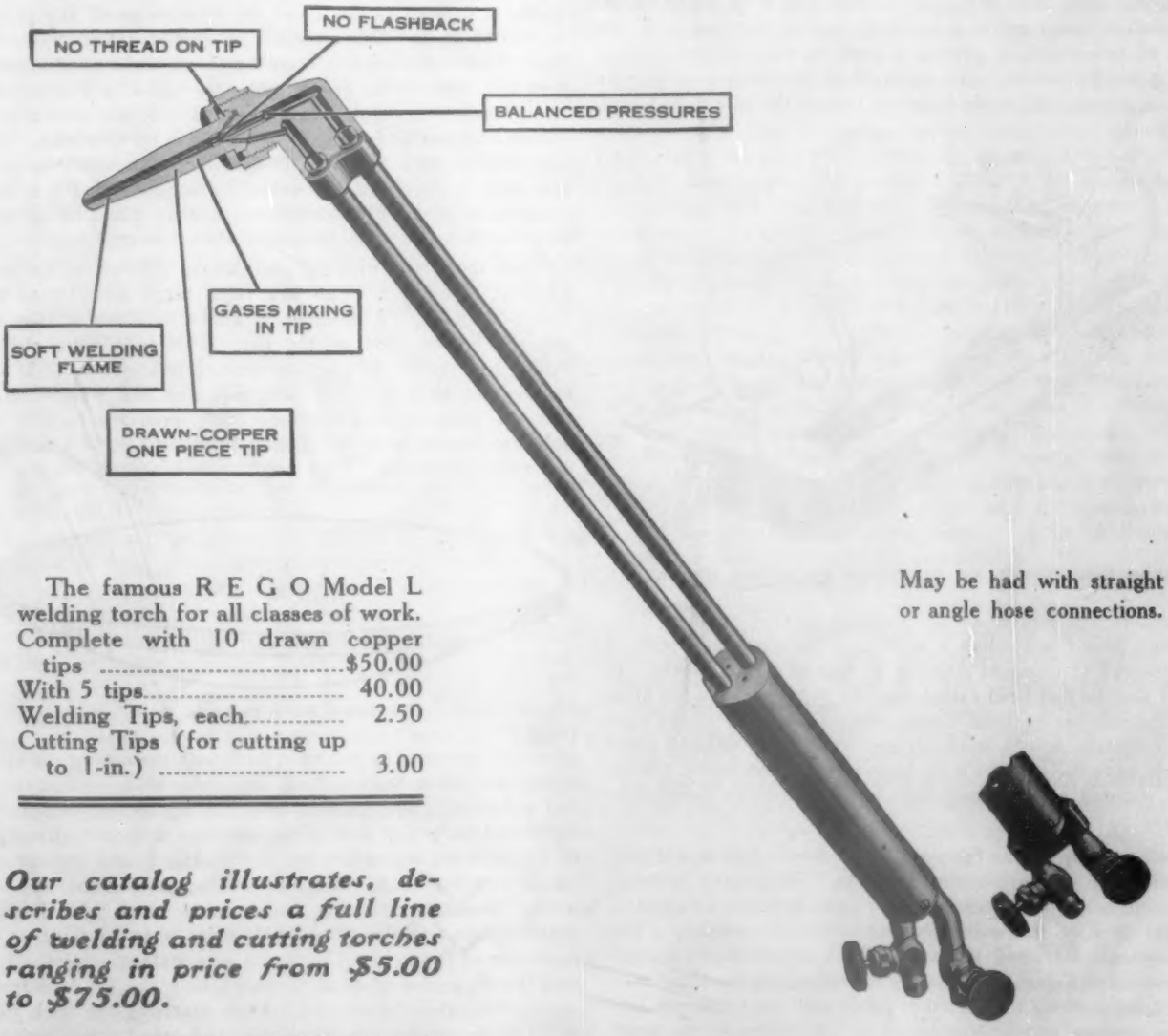

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Welding Tips, each	2.50
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PATCHING TANK STEEL

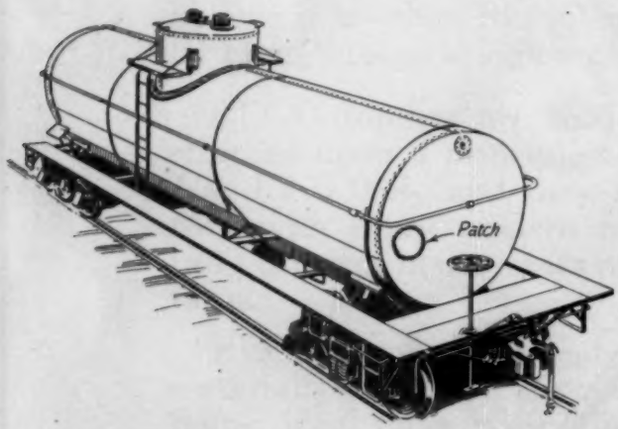
When Applying a Closed Patch the Patch Must Be Dished to Allow Contraction of Welded Area

Atlanta, Ga.

Dear Ed:—

When all is said and done, Georgia isn't such a bad state at that. After traveling over hills and valleys deep and into Atlanta our train did creep, it was a grand sight. Whoever christened it the New York of the South didn't go far off. While Peachtree Street isn't exactly a Fifth Avenue, it sure has its attractions and a fellow can meander up and down by the hour without any thought of tiring—You're right, Ed, perfectly right! I do like Atlanta.

As far as the welding is concerned, Ed, I don't think the process is used so extensively down here as in the North. This, as you might suppose, is perfectly natural for the manufacturing isn't in evidence down here like it is up our way. It's an exception to see a welding shop of any size so I was sort of interested in getting a peek at one particular shop I had heard much of. The manager of this shop had the reputation among the trade of being one of the oldest and best



This Patch Should Not Be Difficult for a Good Welder.

welders in the South, so of course I wanted to meet him. Imagine how I felt when I arrived at his plant and learned that instead of being in Atlanta he was in New Orleans. It seems that he had been called upon to supervise this job after repeated failures by local Companies. There was a bare possibility that he would finish up and come right straight back. If such were the case he'd be back in two days more. Well, Ed, I decided to wait two days but if he didn't come then I'd have to travel on.

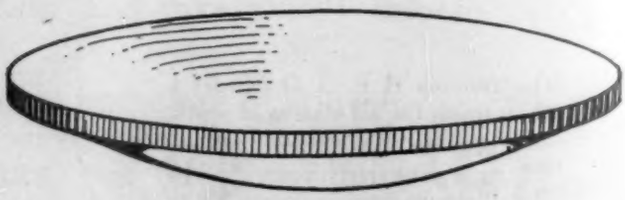
While waiting I was figuring all the while that in addition to having the pleasure of meeting him, he'd have an interesting job to tell about inasmuch as they called him a thousand miles to do a job that evidently was out of the ordinary. The first day rolled around and most of the second had followed the first when I gave up all hopes of making connections with him. I went down to the ticket office and made reservations on the evening train. No sooner did I return to the hotel when I found he had landed. There was no time lost in getting together and we sure had a jolly good talk but it wasn't long enough, that was the only trouble.

I suppose you are wondering about the job he was on. I know I was, but everytime that I'd bring it up he would sort of side track me so I could plainly see that he couldn't be crowded any. I let him take his own time and finally he came around to it.

"You see more is required from a good welder," he said, "than simply a knowledge of how to weld. He must use his head and figure out each problem right on the job. This point was brought out very clearly on the job I was just called in on over at Orleans. There was nothing extraordinary about such a job that they should send for me but the men on the job simply did not try to analyze their difficulty and rather than make the mental effort they sent for me. I don't mind telling you about it for every time I think of it I'm inclined to smile. You too will see the point as I go on."

"It seems that a certain apparatus manufacturer." he went on "figured that it was going to be possible to make a big sale to an Oil Company so the representative was doing everything in his power to get the deal through. In due course a demonstration as to the application of the process was to be made. What should be welded? The superintendent of the Oil Company, it so happened, had a good job right then and there. One of the tank cars had a hole punched in one of its ends and he would like to see just how a patch would be fitted and welded in, in a case of this kind. Why that was no trick at all. The demonstration would be made that very day. That was evidently satisfactory for a short while later, as I had it explained to me. The demonstrator was out there with his apparatus all set to go."

"Now there was nothing particularly difficult in the job," he went to explain. You have seen many an oil tank car. The tank itself, I'd imagine, is about five feet in diameter and the length, that of the car. The ends were slightly bellied but in the center they were just about flat. It was in this flat part that the hole was and the welder seeing that the material was half-inch plate, provided to trim the hole out around with his cutting torch and fit in a patch of the same thickness. This patch was prepared from a flat



The Dished Patch Does the Trick.

piece and arranged to just fit in flush with the rest of the plate. It was welded in the usual way and meanwhile quite a crowd had collected. The distributor of the apparatus was plainly impressed at having such a fine audience and took advantage of the moment to explain the possibilities of the process and his apparatus. Well Sir! the weld was finished and the welder was just gathering up his tools when BANG! The patch let go and the plate cracked for about six inches on each side of the weld. This was a nice state of affairs. How was the Salesman to save his face? here the job was much worse than when he started. Alibi, that was the trick. He spoke to the welder and they suddenly learned that it was the wrong filler rod they used. It was then quite late in the day so it was agreed that they leave their equipment there and return the next day and do the job over.

"Did the same welder tackle the job the next day?" my friend continued. "He did not! The apparatus man scouted up the best welder in town and put him on the job the next day. This welder had welded fire boxes in boilers and what not so there was no chance at all of his work going wrong.

Well, to make a long story short the second day was simply a duplication of the first. No sooner had the weld started to cool off when there was a sudden report and again she cracked. This time the opening was much worse than before. A performance of this kind on company property was to much for the Company. They had visions of their tank being ruined. It was up to the distributor to work fast so he announced that he woud wire the factory for a welder and would guarantee satisfaction. This kept them cool and so he did wire his factory. They immediately sent me a telegram asking me to get over there without losing a minute. Summons of this kind I usually obey even if I don't know any thing about the nature of the work because I always charge a good stiff fee for my services and traveling expenses and not once have they hesitated an instant about paying. This was no exception. I got the next train and after landing on the job it was all fixed up in good shape within three hours and I managed to get a train that same day coming this way. As I said before, these jobs aren't hard but a fellow has to go after them with a degree of intelligence, that's all."

"I'll agree with you there," I said, "but on the other hand you'll have to agree with me when I say that none of us are blessed with any too much of that stuff you call intelligence. Naturally, those who have more than the average stand out head and shoulders above the crowd. Now what I'd enjoy learning is just what you did on this particular job that the other fellow didn't do. We are always learning about some wonderful job being done but the most important part is always left out—It's the details I always crave."

"If there were anything concerning this job that was out of the ordinary I'd certainly be pleased to tell you but really it was just an ordinary patch proposition and the only reason I was called upon to do it was because this apparatus man got a little nervous and crowded his welders too much," was the answer I got.

"Come now!" I said, "you surely did something that the others didn't do. Did you use the same apparatus?"

"Yes."

"How about the rods?" I asked.

"The same kind exactly."

"Did you make the same kind of a patch and fit it the way the others did?" I next inquired.

"I suppose so," he answered. "I cut it out of the same sheet as the others and after getting the blacksmith to put a belly in it I simply tacked it in place and welded right around without stopping."

Determined to get to his actual secret I decided to keep on with my questions so next I asked him why he had to put a belly in the patch.

"Oh it would be impossible to do that job without some means of taking care of the contraction. That's why I bellied the patch," he answered.

"Why would it be impossible in that case? Isn't there enough elasticity in steel plate to take that up?"

"Not in tank steel," he replied. "That's one steel that there isn't much life in. It's not like boiler plate or fire bos steel. If a weld were to be made in tank steel and no provision were made for contraction it would simply open up as fast as you could weld it. Now by putting a good belly in the patch and welding it in place in the usual manner, with the convex side out, the weld is allowed to cool slowly while the torch is played on the bellied portion and this high part is rapped lightly and rapidly with a hammer until it is just flush with the rest of the surface. By so doing, the contraction is taken care of by the mechanical expansion of the patch. It's a very simple thing, anybody would think of it."

"That's the secret," I exclaimed. "The belly is the thing that turned the trick. I'll be that's why the other fellows fell down. They didn't figure that tank steel was so dead."

"I wouldn't be at all surprised to learn that that was the reason," he answered, but just then I caught a twinkle in his eye and saw that he had just been having a little sport with me.

His highness then pointed out that he had just been trying to impress me with the fact that each welding problem, as received in the general run of work, has to be given individual thought and if so handled the results will invariably reward the operator for any trouble he has been put to.

Drop me a line to New Orleans Ed. I'll be there a week or ten day this time. Better make it general delivery as I'm not just sure where I'll put up at.

Cordially,
SHEP.

P. S.—Just happened to remember that there was another point brought up later in our conversation that was evidently looked upon with considerable importance. It had to do with annealing the part adjacent to the weld with the torch before starting. The heat given off during the welding is apparently not sufficient, therefore, this added treatment.

AMERICAN WELDING SOCIETY FALL MEETING

The officers and directors of the American Welding Society have expressed themselves as being highly pleased with the good work accomplished at the fall meeting of the Society held in Chicago the first week of this month. The program of this meeting was printed in full in the September issue of *The Welding Engineer*. Some of the most interesting and satisfactory features of this program were the meeting of the committee on specifications for steel to be welded; a meeting on the subject of sectional research, the afternoon and evening sessions on the various methods of welding cast iron, and the meeting of the committee on the training of operators. The committee which has been studying steel for welding has so far devoted its time to determining what quality of steel acts in the most satisfactory way when heated to the point of fusion. The tests made so far indicate that whether heated by electricity or by the gas flame, commercially pure iron has the most satisfactory reaction. Further tests will be made with welded specimens before the report is completed. The committee on training operators has prepared a fairly complete outline of instructions for welding various metals, this outline to serve as a guide for the instructor rather than as a text book for the beginner. It is planned to organize a vigorous campaign for memberships in which the national headquarters will co-operate with the membership chairmen of the local sections to make the campaign as effective as possible.

On Tuesday morning, the electric-arc welding committee and the gas welding committee met jointly for the purpose of developing regional research committees in the Chicago district. This is in accordance with a regional plan of research developed by the American Bureau of Welding, which differs from the ordinary committee work in that the members of each regional committee live within a given locality and at no great distance from a common meeting place. The advantage of the plan is that it permits the holding of regular frequent meetings without unnecessary loss of time, it permits the sustained interest of members, as the frequency of meetings and their regularity do not allow time for the members to forget what happened at the previous meeting, it permits a particular investigation to be carried to a successful completion within a short time, and promotes interest in research in a particular locality at a minimum of cost. Such a regional committee, known as a sub-committee on the electric-arc welding of cast iron, was organized about a year ago under the auspices of the Northern New York Section of the American Welding Society. Members of the committee consist of representatives of the General Electric Co., the American Locomotive Co., West Albany shops of the New York Central Railroad, one or two foundries and Union College. Meetings are held fairly regularly at intervals of two weeks.

In the afternoon session a joint report of the gas, electric and thermit welding research committees on the general properties of cast iron in so far as they affect weldability, was read. It was

(*Continued on page* 32.)

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The High Cost of Ignorance

IT is always the well trained operator who gets the best result out of his torch with the least expenditure of time and gas. The torch is a handy tool either for routine work or for emergency, but it becomes expensive when turned over to a workman who is not thoroughly posted on the correct method of operation. Let a single instance out of recent experience be taken as an example. A manufacturer who had been accustomed to using oxy-acetylene welding on a small scale, was suddenly confronted with an emergency necessitating the temporary addition of a large force of welders. These "welders" were put to work with only the briefest kind of instruction. A visitor in this plant, while the emergency work was being done, noticed that workmen were walking around between jobs with torches lighted and starting in on new work without even a glance at the flame. Tips were being used after having been melted and battered beyond usefulness, and nobody seemed to be exercising any supervision over any of these points. Altogether, this work was costing about three times what it should have cost. Everybody seemed to be satisfied with the progress that was being made, so that the company was probably making money. If the plant manager had given a little more attention to the welding process, however, he would have been able to save at least two-thirds of the cost of the entire job.

Welding Goggles Can Correct Vision

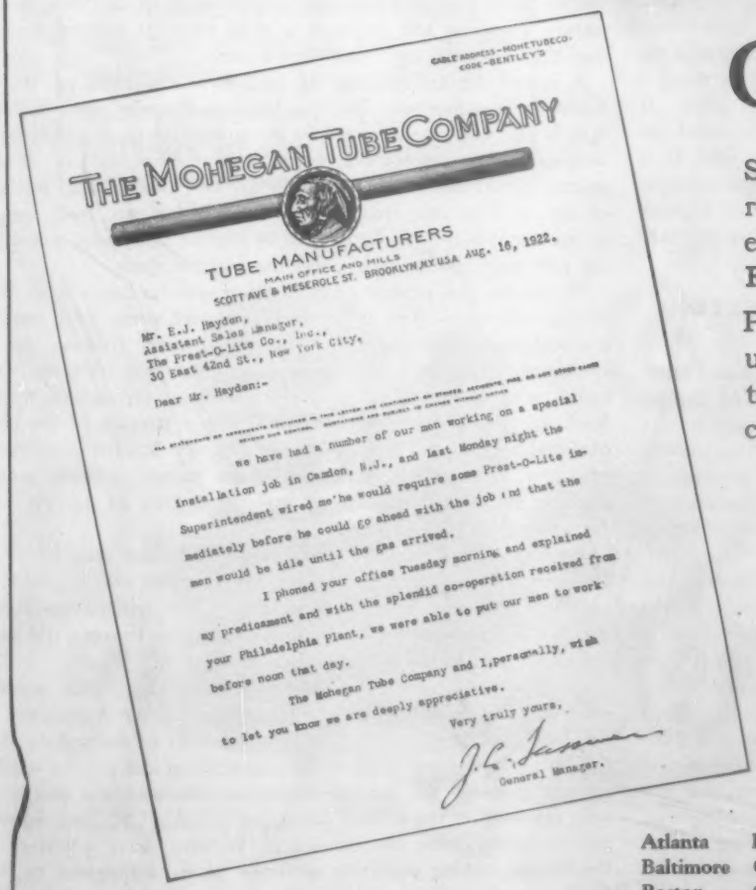
ONE of the articles in this issue mentions a "sense of fusion" is a qualification for a good welder. It should not be overlooked that this sense of fusion depends a good deal upon good vision. Faulty vision is a very common thing among people in all walks of life, and as a general rule only those who use their eyes for constant reading will take the trouble to correct their vision by properly fitted glasses, unless the imperfection is so great as to cause marked discomfort or inconvenience. It does not seem to be generally known that it is possible to have welding goggles made which will protect the eyes from the glare, and at the same time correct imperfect vision. It is true that such goggles will be more expensive than plain colored glass but the investment is small compared to the possibility of making good welders out of poor welders.

Constructive Development of the Welding Process

ITt is generally recognized that welding has come to be such an important factor in our big industries as to call for considerable investigation of the possibilities of perfecting all of the various processes. The users of the processes will agree that this is necessary, yet, if this investigation work was left to individual users it is doubtful if the benefits of it would be at the disposal of the various industries interested. The American Welding Society offers an opportunity for all users to co-operate in making investigations at a very small cost to the individuals, and to the great advantage of all of them. It is the desire of the American Welding Society to enlist the support of the users as far as possible, and to direct it's activities in such a way that the users will be the beneficiaries.

The organization of the American Welding Society in the local sections in our industrial centers, gives the users an opportunity to keep in very close touch with all of the Society activities, and to derive benefits which are not available from many of the national engineering associations. Monthly meetings held in these large cities supply programs, which, in the course of the year, are worth a good deal more than the cost of membership. Some of the interesting problems which have been discussed in the section meetings already, are of such a nature that it at once becomes apparent that large users can hardly afford not to belong to this Society and thereby gain the benefit of the papers and discussions.

As members of the American Welding Society have gained experience in the handling of discussions of problems, the nature



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of the discussions have changed very much for the better, and it is now considered that papers and discussions can be expected to be always of a constructive nature rather than controversial. On the basis of work already done, it is safe to say that all users who join this Society reap benefits that will much more than compensate for the dues paid, and by increasing the membership so that many users having quite similar problems will be able to get together in the various districts, the value of the Society will be further increased.

In order to indicate the great variety of problems which have already been investigated, and the possibility of further development of the four welding processes, a number of the papers and discussions presented at the recent fall meeting of the American Welding Society in Chicago are reproduced in this issue of *The Welding Engineer*. There are many problems relative to the testing of material, correct designs for welding, and countless other things, which will certainly be taken into consideration in the meetings o fthe Society in the year to come. The past year has been full of accomplishments of worth while things. More memberships will make possible more successes. Every firm which is interested in the further development of the welding industry, should demonstrate its interest in a practical way, by applying for a membership.

Training Operators

WHEN new operators are to be trained for the welding department, a first-class welder is usually delegated to do the training. It would be helpful to supply him with some good suggestions on systematizing this instruction work. If he is left to his own devices his instruction is not apt to follow any regular course of procedure. A written outline of the course of instruction will be extremely helpful, and will greatly increase the value of the time devoted to training the operator. One thing it will do is to prevent the instructor omitting important steps. It will also enable the foreman to determine exactly how much instruction each man has had when he comes into the job. It is not to be expected that a good welder can develop a real scientific instruction course all by himself, but it is possible to increase his value as an instructor by helping him to put some system into his work.

AMERICAN WELDING SOCIETY FALL MEETING

(*Continued from page* 29.)

pointed out that cast iron differs widely in composition and characteristics. It always contains about three per cent of carbon, but this may be either in a combined graphitic state and it may hold widely varying amounts of other elements, such as silicon, manganese, sulphur and phosphorous. Not only the presence of these elements, but also the rate of cooling of the casting profoundly affect the physical characteristics and weldability of the metal.

In making a weld in commercial cast iron, the surfaces which are to be joined must again be melted. These surfaces consist of iron which contains carbon in both the free and combined states. When these surfaces are melted, several things happen. First both the graphitic and combined carbon go into solution in the molten metal. Second, some of the caron, silicon and manganese is burned out by the heat, while the amounts of sulphur and phosphorus are practically unchanged. Silicon is most easily burned out, so the tendency is to produce cast iron in the weld that will be white when cold, owing to its low silicon and carbon content. Third, the surface of the molten metal oxidizes, making a slag, which in a measure prevents further oxidation. As soon as the welding heat is removed, the melted iron solidifies very quickly, owing to its proximity to the comparatively cold mass from which it has been melted and to its being exposed freely to the air. This sudden cooling causes a large amount of carbon to be retained in the combined state, resulting in a white, hard metal in the weld. Of course, if the casting has been pre-heated before welding, the cooling of the added metal will not be so sudden and a softer machinable weld may be secured. Experience has shown that the grade of cast iron which is most difficult to weld successfully is that which is soft and has an open grain. However, little difficulty is encountered when the metal is of comparatively thin section (½ inch or less).

The shape of the castings also has an influence on the method of welding to be used. A casting comprising both light and heavy parts is subjected to more external stresses than one of homogeneous cross-sections. The stresses are caused by the different rates of cooling, light sections cooling more rapidly than heavy. There are also internal stresses set up at sharp angles.

Acetylene for Cast Iron Welding

A progress report of the research committee on gas welding of cast iron was read by the chairman, S. W. Miller, Union Carbide & Carbon Research Laboratories. In the opinion of the committee, acetylene is the best gas for welding because of its high flame temperature.

The use of the oxy-acetylene flame for preheating is expensive even for small work, and for the sake of economy, other cheaper methods are used.

The greatest difficulty in cast-iron welding is to take care of the slow strains which occur during preheating, welding and cooling. Slow preheating, rapid welding followed by slow cooling, are the means to be employed, especially in restrained welds. In such welds, either strains or distortion can be prevented, at least for practical purposes, but it is not possible to avoid both. Strains, being dangerous, should always be avoided, even if some distortion is necessary. In concluding, the committee asserted that with thorough fusion, proper allowance for expansion and contraction, adequate preheating, slow cooling, use of proper welding rods and no more flux than necessary, the welding of cast iron is uniformly a success and produces a weld which is always stronger than the base metal and readily machinable.

A report on arc welding of cast iron was read by W. H. Namack, vice-president, Davison-Namack Foundry Co., Ballston Spa, N. Y., and chairman of the sub-committee on the electro-arc welding of cast iron of the Northern New York section. It was pointed out in this report that there are two fundamental methods of arc welding cast iron, first, by the carbon arc, and, second, by the metal arc. The latter may be divided into metal arc welding with studs and metal arc welding without studs.

The carbon arc process gives better results on heavy work than the metallic arc. The employment of steel studs with metallic arc welding is for the purpose of overcoming troubles due to shrinkage. The studs are screwed into the cast iron, the filler metal being welded to them. These studs pass through the brittle layer of iron at the weld and transfer the stresses to the mass of metal back of the weld. The report gives detailed descriptions of typical arc welding operations by the various methods, outlining the difficulties encountered and the degree of success thus far achieved.

A report on thermit welding of cast iron was read by J. H. Deppeler of the Metal & Thermit Corporation, who is chairman of the committee on thermit welding. He outlined researches which are being carried out by his company to improve the quality of thermit welds and to reduce their cost.

On Wednesday and Thursday the society held joint sessions with the American Electric Railway Engineering Association at the Municipal Pier. C. A. McCune, president of the society, outlined the purpose and scope of his organization and pointed out the manner in which the electric railway association might co-operate with his body to the mutual advantage of each. William Spraragen, secretary American Bureau of Welding, gave a history of the bureau, calling particular attention to its willingness to conduct research in fields of interest to the electric railroads. The co-operation which both speakers advocated, has already taken form through the membership of a representative of the railway engineering association on the welded rail joint committee of the American Welding Society. This member, E. M. T. Ryder, way engineer, Third Avenue Railway System, New York, who is also vice-chairman of the committee, addressed the joint session on welded rail joints.

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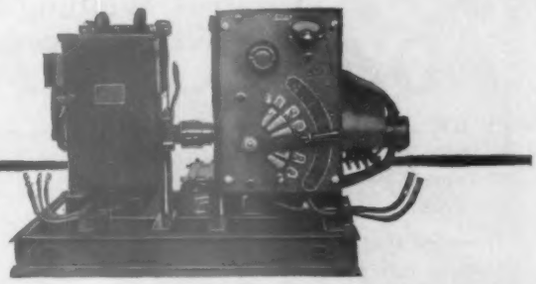

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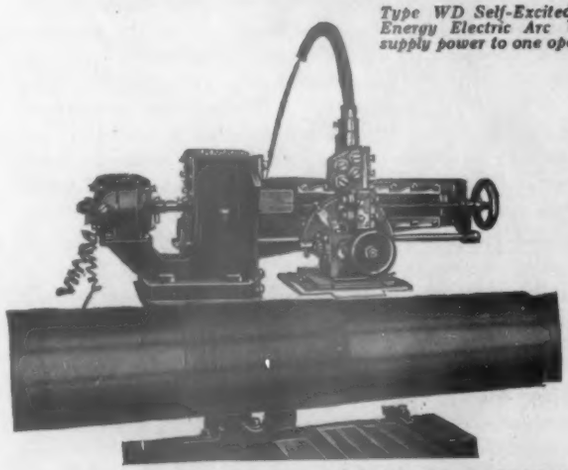

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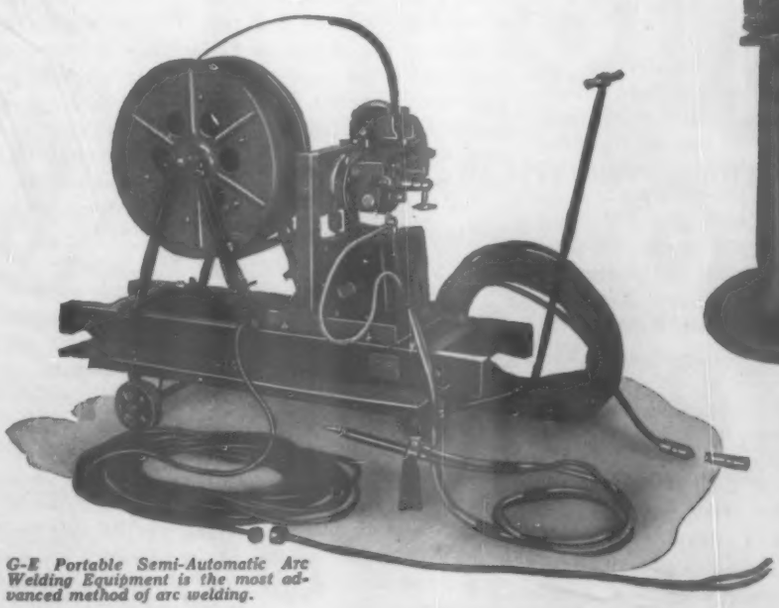

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MAINTENANCE OF 1600 STREET CARS*

Central Welding Shop Handles Great Bulk of Repair Work Necessary for Upkeep of Entire System

By J. S. McWhirter†

THE American Welding Society has requested that I tell you something of welding as we have found it from our experience on the Third Avenue Railway System of New York.

In order that you may understand something of our conditions, I will say that the Third Avenue Railway operates approximately 1600 cars in the City of New York and in several of the adjoining municipalities. Forty-six per cent of the cars are operated by the underground conduit system, forty-nine per cent by overhead trolley and the remaining five per cent by storage battery. Overhauling, reconstruction and all but minor repairs are done at a central repair shop located at 65th Street and Third Avenue, in the Borough of Manhattan. This centralization of overhauling and maintenance has simplified our requirements for welding facilities.

We started electric welding in 1915, using the carbon arc with graphite electrodes, the current being obtained from the 600-volt railway circuit by stepping down the voltage through second hand car resistances. At present we are doing forty per cent of our welding with the graphite electrode, fifty-five per cent with the metallic electrode and five per cent with the oxy-acetylene torch. Our equipment consists of five constant energy, 200-ampere, individual motor generator sets and two constant potential motor generator sets, one of 300-ampere rating and one of 400-ampere rating. There are still in use two banks of resistances fed by the railway circuit, but we are planning to replace these resistances as fast as the development of the art and operating economy justify the change. Our leaning is towards individual motor generator sets because of the superior regulation of the arc which is obtained with the individual set as compared with the larger motor generators.

We have one oxy-acetylene welder. The greater part of his time is spent in repairing bronze armature bearings, bronze brushholders and other bronze parts. We find it more practicable to use the oxy-acetylene torch on bronze than the electric arc, because of the objectionable fumes which result when bronze is welded with the arc. The oxy-acetylene operator also does all but the roughest cutting and the few steel welds which are inaccessible to our electric arc welders. But we prefer the electric arc for the welding of the average truck or car body part, the electric arc in our case doing the work at about two-thirds the cost of the oxy-acetylene torch.

The foregoing briefly outlines our development. You will note that we started electric welding with the graphite electrode and that we have gradually changed over toward the metallic electrode. Our only reason for continuing the use of the graphite electrode is the speed with which metal can be deposited, but this advantage is limited by the requirement that the graphite electrode must not be used where the welded part will be subject to stress.

Our organization consists of one foreman, who devotes about sixty per cent of his time to other work, one semi-automatic welding machine operator, four metallic electrode welders, two carbon arc welders and the one oxy-acetylene welder. With this organization we are able to do all the welding that is necessary for the maintenance of our 1600 cars and a normal amount of reconstruction. I might amplify this statement by saying that his organization will take care of all the welding which we believe is economical to undertake. It is our experience that welding is not justified in all cases where surface indications point to its use.

The volume of work turned out by our welding organization is best measured by the pounds of welding metal used per year, which runs with us about 25,000 pounds of bare soft steel welding and 1500 pounds of manganeze bronze. The average amount of metal used per operator with our three types of welding is as follows: with the metallic electrode, 1.2 pounds per man per hour, with the graphite electrode 1.6 pounds per man per hour and with the oxy-acetylene torch, 0.6 pounds per man per hour.

Our biggest routine welding job is the rebuilding of worn axle bearing seats on cast steel motor shells of sixty-five horse power motors. We weld two of these shells a day, one operator hand welding with 3-16 inch metallic electrodes and one operator working with ⅛ inch metallic electrodes fed by the semi-automatic welding machine. We would prefer to do this job with the full automatic welding machine, but the concave surfaces of the axle bearing seats do not permit the use of the full automatic. While our results to date have been satisfactory, it is to be noted that the hand operator accomplishes as much work per day as the man using the semi-automatic. But the hand work welder is working close to the limit of hand welding capacity to accomplish this result, while we contemplate increasing the capacity of the semi-automatic machine by thirty per cent.

The welding and reinforcing of cast steel and forged truck frames and of cast steel motor frames has been practiced since 1908. In 1908 and 1909, a large number of these were welded by the old Goldschmidt-Thermit company under contract and these welds have given satisfactory service. When we started electric welding, we welded these parts with the graphite electrode, but the breakages were excessive. We now weld them with ⅜ inch metallic electrodes and secure very satisfactory results. It is our opinion that it is cheaper for us to use the metallic electrode process for this work than the thermit process.

The welding of gear cases has proved very economical. Our annual saving on gear cases alone is about $12,000. While the majority of our gear cases are of malleable iron, we are able to do a fairly satisfactory welding job on patches and reinforcing pieces by using a good grade of coated metallic electrode. We do not depend upon these welds for strength.

We have had some experience welding axles. When the automatic welding machine was first developed we installed one on a second-hand lathe and started it welding worn driver axle bearing seats. The deposited metal was laid on in the form of a screw thread as the axle revolved in the lathe. This part of the work was very economical, as the nine hour welding job required but one hour of a man's attention.

These axles were AEREA, standard Number E-A and up to the time that we started welding had never broken in service. A careful record was kept of all welded axles and without exception the welded axles broke through the welds after six to nine months' service. In some cases this was due to faulty welding; a fault not of the welding machine, but rather of inadequate control between the lathe feed and the automatic welding feed. But the majority of the breakages were through perfect welds.

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*Paper presented at joint session of A. W. S. and American Electric Railway Engineering Association Chicago, Oct. 4, 1922.

†Superintendent of Equipment and Buildings, Third Avenue Railway System, New York, N. Y.

HYDROGEN FOR LEAD BURNING

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Electrox Co., Peoria
National Oxygen Co., Chicago
Swift & Co., Chicago

INDIANA
Indiana Oxygen Co., Indianapolis
Logansport Oxygen Co., Logansport

IOWA
Bettendorf Oxygen Hydrogen Co., Bettendorf

KENTUCKY
Kentucky Oxygen & Hydrogen Co., Louisville

LOUISIANA
Louisiana Oxygen Co., Inc., New Orleans

MANITOBA
Auto-Lite Gas Co., Ltd., Winnipeg

MICHIGAN
Burdett Oxygen Co., of Detroit, Detroit
Michigan Ox-Hydric Co., Muskegon
National Oxygen & Machinery Co., Detroit

MINNESOTA
Commercial Gas Co., Minneapolis

MISSOURI
Kansas City Oxygen Gas Co., Kansas City (two plants in Kansas City)
St. Louis Oxygen Co., St. Louis

MONTANA
Mountaineer Welders' Supply Co., Butte

NEBRASKA
The Balbach Co., Omaha

OHIO
Clarke Chemical Co., Wickliffe
Ohio Electrolytic Oxygen Co., Cincinnati

OKLAHOMA
Burdett Oxygen Co., of Oklahoma, Oklahoma City
Tulsa Oxy-Hydro Co., Tulsa

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National Oxygen Co., Erie

TENNESSEE
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Investigation of the cause of these breakages show it to be due to the quenching action of the mass of the axle upon the surface of the axle subject to the heat of the arc, the result being a hard and brittle layer of metal surrounding the axle immediately under the soft deposited metal. Investigation further showed that this hard layer could be successfully removed by annealing the welded axle under close temperature control. But after the axle was annealed it was necessary to straighten out the warpage caused by the annealing and to true the bearing surface in a lathe. When the cost of the labor, material, electric current and equipment required to reclaim the axle, was totaled, it was found that the saving was only about twenty per cent of the final cost of a new axle.

We reclaim a large number of brake shoe heads, brake beams, side and center bearings, journal boxes, step hangers and other truck and car body parts. We estimate our annual net saving on these parts to be about $45,000.00. This saving is after deduction of other shop labor on the reclaimed material and the deduction of a liberal allowance for maintenance, depreciation and fixed charges on the welding equipment, wages of foremen and clerks, superintendence, building rental and our other items of overhead.

To secure the maximum benefit from the reclaiming of truck and car body parts it is necessary that all parts which are to be welded be made of cast steel or forgings, in place of the malleable iron which is so common in electric railway car equipment.

Our experience with welding malleable iron has been that while it is possible and often necessary to weld this material, the welds do not possess sufficient strength to justify the welding on a large scale.

The advantages of welding for emergency repairs are well known. A single instance of our experience will illustrate this point. One afternoon the four foot cast iron fly-wheel of the paper cutter at our printing plant was broken, thus completely tying up the printing of our transfers, no replacement part being available, short of a six weeks delivery. By reinforcing the wheel with steel plate, liberally studding and working half the night, we were able to have the paper cutter in operation the next morning. This repair has now been in constant service over two years without a failure.

In a paper of this kind, there is very little room for a discussion of the technical features involved, but those who are interested will find a clear statement of the physical changes produced in steel by welding in the very able paper, which was presented before the Chicago Section of the American Welding Society in 1920, by Mr. T. D. Sedwick, Engineer of Tests, Rock Island Lines. Mr. Sedwick take up the question of pre-heating and annealing in detail. And our experience has been in line with his conclusions.

In conclusion, it must be said that electric welding proved a life saver to us during the war periods of inflated prices and slow deliveries. We undoubtedly did a large amount of welding in those periods which would not be justified today, but it is a tremendous benefit to the electric railway industry to have available welding facilities which will take care of such emergencies.

THE USE OF THERMIT WELDING IN STREET RAILWAY SHOPS*

J. H. Deppeler†

THERMIT welding is used extensively for reducing maintenance costs in street railway shops throughout the country in making up special work, welding arms to broken mates, welding compromise joints when needed and for repairing car truck frames, electric motor cases and for other useful purposes too numerous to be mentioned.

Making Special Work by Means of Thermit Welding

One of the most striking developments of Thermit welding has been the remarkable spread of this process for welding sections of rail to form frogs and single and double track crossings. The advantages of boltless, jointless, Thermit welded tracks are particularly noticeable in the case of special work because Thermit welded frogs can be constructed at only a fraction of the cost of manganese or other special work. Furthermore, service tests of over seven years, under heavy traffic conditions, in Milwaukee, Indianapolis, Youngstown and other cities have conclusively shown that Thermit special work has held its own in comparison with other installations costing two or three times as much; in fact it has outlasted manganese insert frogs installed in the same place and subjected to the same service.

Thermit welded special work can be made in the railway shops and the completed layout then transported to the street and quickly set into position and welded to the adjoining rails with minimum delay to traffic. In the case of double track crossings, two halves of the crossing can be constructed in the shops and the projecting arms of each half later welded together in the street. A Thermit welded crossing welded into place will give years of satisfactory service and as compared with any other installation, will save many times its cost.

It is obvious that with a fully welded installation of the kind mentioned above, no conductor cables are required, as all joints will have the full electrical conductivity of the rail itself. This is another advantage which should not be ignored.

Thermit Welded Compromise Joints

Another shop use for Thermit Welding is in connection with making up compromise joints.

Probably no problem connected with street railway work causes more annoyance and expense to the "way department," in proportion to its magnitude, than the proper maintenance of compromise joints. While at first thought, it might appear that the number of these joints on the average street railway system is so small as to be practically negligible, it is a fact that actually there are a great many more than would be reasonably expected. The reason for this is not difficult to find. Owing to the very rapid development of electric traction, with the consequent increase in the weight of rolling stock and speed of operation, it was necessary to increase the size and depth of the rail accordingly. Requirements of modern pavement also demand frequent changes in the design of the rails, so as to offer as little interference with vehicular traffic as possible and still provide a good track. The result is that there is hardly a street railway system in the country that has not a great variety of sizes and types of rail in its track and wherever these various sections come together a compromise joint is necessary.

When it is considered that for every change of section, two compromise joints on single track and four on double track are necessary, it will be readily understood that, on the older street railway systems particularly, there must be a great many of these joints.

Mechanical joints have not proved satisfactory, as the plates are seldom accurate and it is exceedingly difficult to obtain either a forged or cast plate which will hold the rails to gauge or surface. Another serious objection is the difficulty of obtaining a satisfactory bond. The Thermit Insert Process, however, will overcome the objections to every other type of joint, with the added advantage that the welds can be made by the street railways themselves either in their shops or in the street and can therefore be had at a minute's notice and without the necessity of carrying a stock of special plates or special cast joints designed for this purpose.

**Discussion of "Welding for the Maintenance of 1600 Street Railway Cars" by J. S. McWhirter.*

†Chief Engineer, Metal and Thermit Corporation.

Motor Cases and Truck Frames

Third and fourth important uses of Thermit welding are in connection with welding motor cases and truck frames broken because of stresses from shock and vibration caused by excessive wear of various equipment parts. Crystallization is also caused by vibration and additional strains then cause breakage. Most breakages occur through the actual bearing bore at the gear end of the motor where one end of the gear case is supported. In many cases, these broken motor cases and truck frames can be repaired by Thermit welding at a great saving as compared with the cost of a new section.

OXY-ACETYLENE WELDING IN ELECTRIC RAILWAY SHOPS*

WE HAVE all read with a great deal of interest, I am sure, the frequent published accounts of the wonderful progress that has been made by electric and thermit welders in the electric railway field. Some years ago, we were equally impressed with the various trade journal accounts of oxy-acetylene welding and cutting in the construction, operation and maintenance of the street railway, concerning which we now read comparatively little in the public prints.

Doubtless, therefore, it will be a surprise even to some of the rapid transit men in this audience to learn that there is actually more gas welding and cutting in electric railway shops in the country today than ever before in the history of the process. This is not true of some individual shops, perhaps, but that it is true of the country as a whole is proved by the steady growth that has obtained in the volume of sales of oxygen and acetylene to electric railway companies. The fact is that all three of the processes—oxy-acetylene, electric and thermit—have steadily increased in both utility and application in the electric railway field.

I think that it is now generally agreed by welding engineers who have made an impartial study of all welding processes, that each logically occupies a rather definite field. Thermit welding, for instance, is generally conceded to be superior for the joining of very heavy steel sections where the conditions are favorable for its use. Electric welding, especially in an industry where electric current is generated in the regular course of a company's operations, as in the electric railway field, possesses certain advantages of economy over other processes in places where it will stand up under adequate service tests. On the other hand, gas welding and cutting are almost indispensable for a very considerable list of operations, particularly for cast iron welding and for reclamation work where welded joints are subjected to unusual strains and vibration and of course, to all wrecking and demolition work.

While electric and thermit welding have been gaining ground, and even displacing oxy-acetylene welding in some directions, gas welding has more than held its strong position in the electric railway industry by virtue of the remarkable development of reclamation operations, which has resulted from the extension of modern efficiency methods. Very likely some of you may be inclined to take issue with me on this point, because there are instances where master mechanics personally favor a single process for all welding operations, irrespectively of its greater or lesser fitness in any particular case. It is only natural in such instances that he should incline to the electric process, because of his familiarity with electricity, the availability of the current and the apparent economy of the arc.

I feel quite sure that any unbiased inquiry into welding in the electric railway field will yield convincing evidence that the companies which are obtaining maximum ultimate economies are those which are intelligently applying each of the three processes where it is called for by the best established practice. There will always be a no-man's land between a distinctly oxy-acetylene and a distinctly electric application and it may possibly be a broader zone than the rather finely drawn line dividing oxy-acetylene and thermit welding applications. The overlapping of the thermit and electric processes, on the other hand, again tends to widen. All these afford battlegrounds for controversy and tend to distract attention from the broader facts that lie unchallenged by experience and engineering knowldge. To me the situation appears clear as to the importance and practical necessity for all of the welding processes that are at present available in electric railway work.

It may be of interest to some of you who, perchance, do not at present use oxy-acetylene welding to a very considerable extent, for me to enumerate a suggestive list of operations that are of daily occurrence in the gas welding departments of some of the country's large electric shops. I shall not attempt to make the list complete but it will suffice as an illustration.

For example, one street railway company in a large city of the Central West has conducted a central welding shop for the past eleven years, employing the oxy-actylene process on such application as

Building up journals on car axles;

Reclaiming truck sides—repairing when broken and building up when worn;

Repair and reclamation of transom bars;

Reclaiming cast steel motor shells—repairing when broken and building up when worn;

Building up bolster ends;

Repairing broken cast-iron motor shells;

Building up armature shafts;

Building up worn equalizers and radial bars at ends;

Building up worn flanges on wheels;

Construction and repair of gear shields;

Repairing truck ends;

Restoring worn ends;

Reclaiming worn brake shoes;

Repair and building up of axle caps, air compressor, gear case and other lesser parts of car frames.

Another very large electric railway company, one of those in an eastern metropolitan center, employs the oxy-acetylene process in welding of:

Pedestal liners; expansion jaw bolts; journal boxes; tube insertions; C. I. gear teeth and breaks; brake cylinders; power station cylinders; equalizer bars and parts; door bars; fly carriers; expansion bars; rail draw bars; wheel press bases (repairs); tool steel tips to mild steel shanks (in machine shop); all bars and bearings; filling in pin-holes, sand holes and flaws in castings, etc.

Yet another street railway company in one of the larger New England cities employs oxy-acetylene welding for:

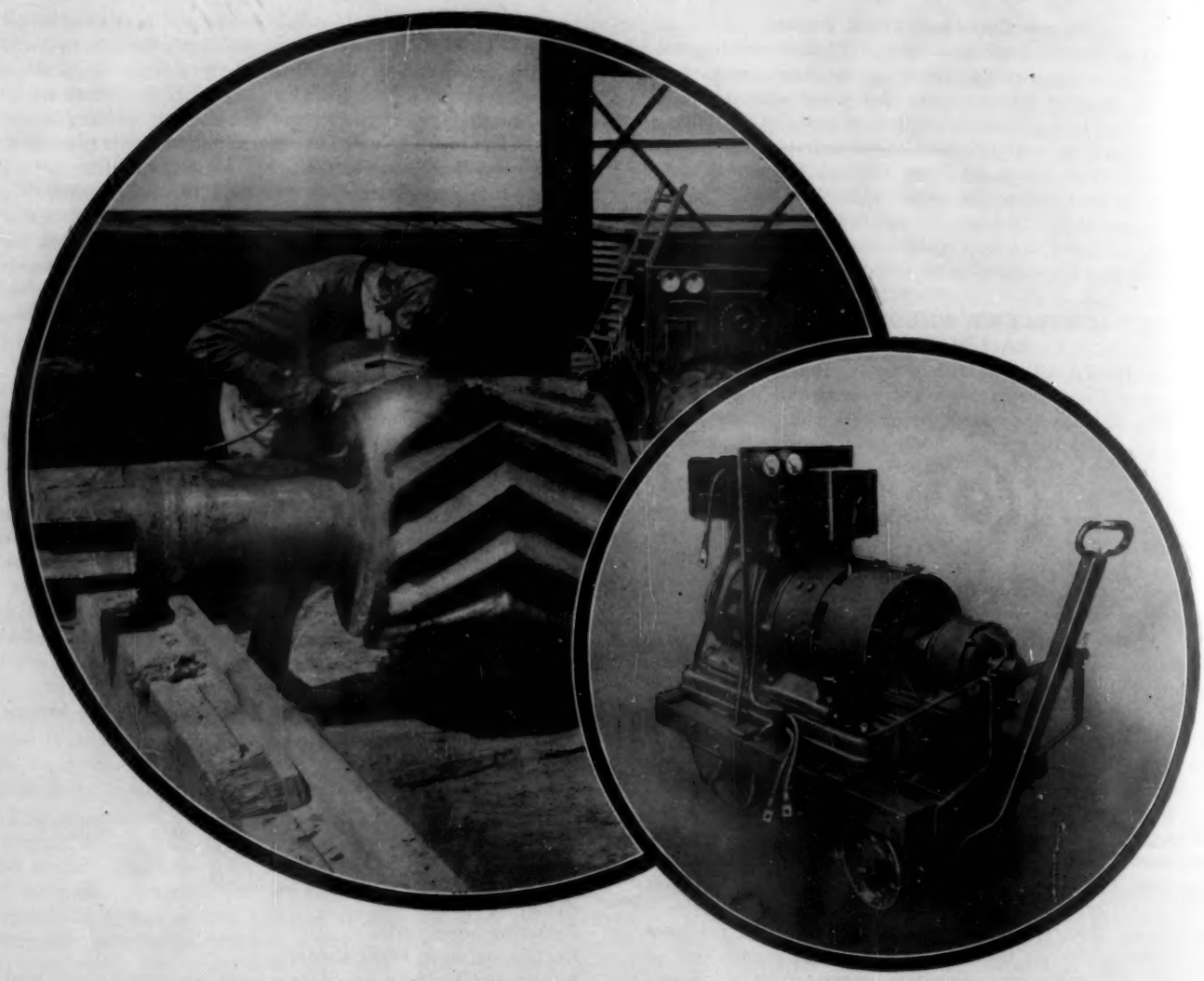
Welding broken gear cases; welding lugs onto gear cases; welding lugs onto hand hole covers; welding transformer boxes; welding motor cases, axle caps, air governors, chair posts, brush holders, axle bearings and armature bearings.

It will be noted that there are comparatively few duplications in the applications enumerated as being used by these three companies. Wherever oxy-acetylene is used to any considerable extent one almost always notes some applications that are not commonly employed in other places, though very often the opportunity is present. A complete list of all of the applications that are being successfully employed in the use of oxy-acetylene by the leading users of the process in the electric railway field would be an imposing one.

Bearing in mind that the companies which are using oxy-acetylene most extensively also have their well-ordered electric welding departments and the fact that both gas welding and electric welding are growing in volume—and the same is

(*Continued on page* 46.)

Paper read by T. Gillespie, Sales Engineer of the Oxweld Acetylene Company, before the Joint Meeting of the American Welding Society and the American Electric Railway Engineering Association, at Chicago, October 4, 1922.



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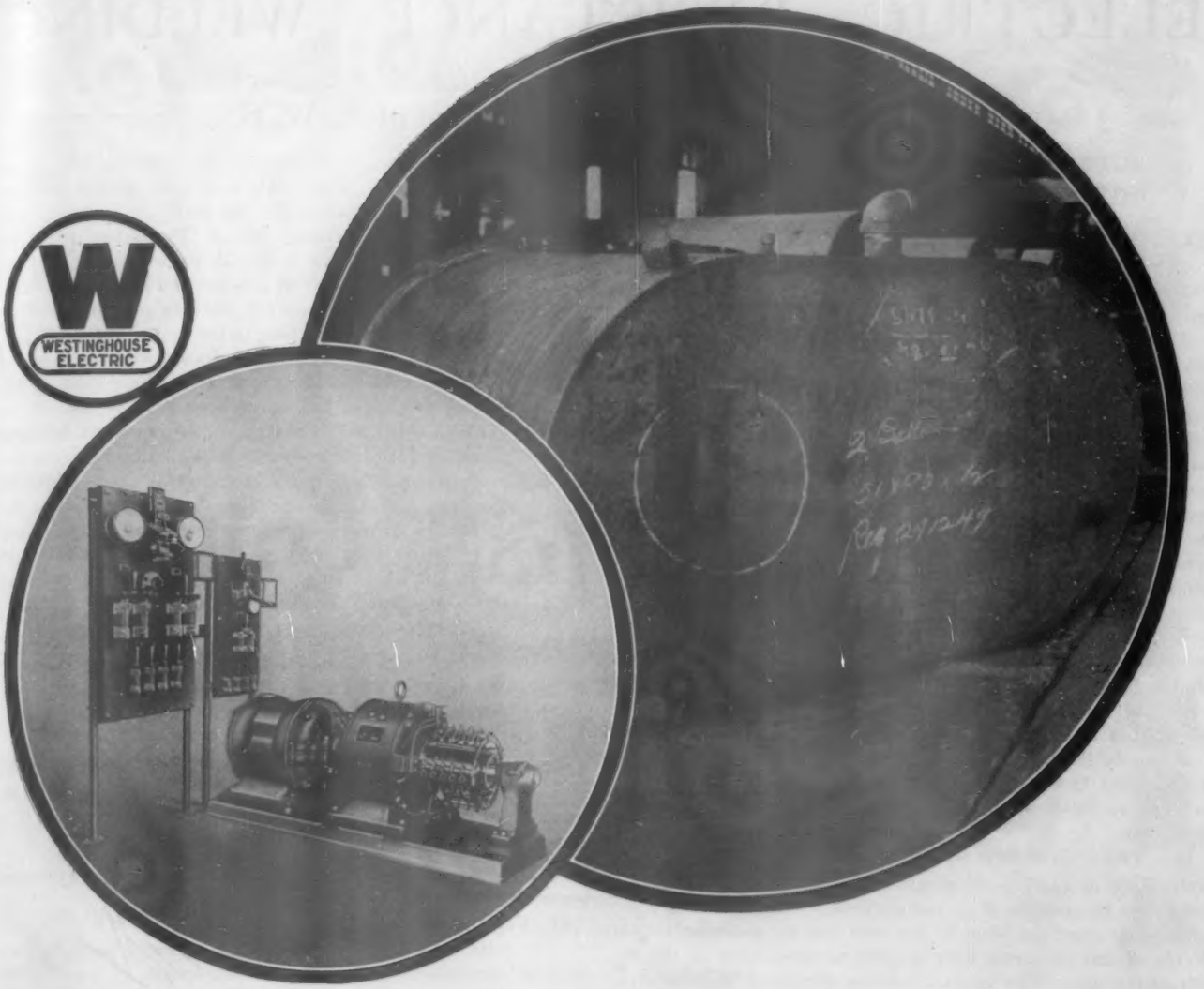

Assist the Operator

erator any current he may desire at the arc, or a single, steady current for a full day's work from a single rheostat. This flexibility is one of the distinct advantages of Westinghouse Welding Equipments where the Welding work is variable.

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BUTT WELDING—SLOW BUTT METHOD

I. Welding of Two Pieces of Same Material and Cross Section

(A) Ferrous Metals:

(1) *Solid Cross-Sections.*—(Rounds, squares, parallelograms where difference between altitude and length of base is not too great.)

Parts to be welded are clamped in dies of welding machine, giving equal projections to both parts, the ends of which are then brought together, current applied, the joint allowed to reach a welding heat, when rapid and heavy pressure is applied, forcing the ends together and completing weld. At the same instant that pressure is applied, the current supply is stopped. The proper projection of parts will vary from a length somewhat greater than their diameter of thickness in small sections to a length somewhat less in large sections. On all round, equilateral, or nearly equilateral sections, having considerable areas, parts should have at least two diametrically opposite, or nearly diametrically opposite, lines of contact, with current carrying dies to insure even heating over entire cross-sectional area. In case the abutting ends do not heat evenly, due to highly localized points of contact between their faces, this can be corrected by what is known as "nursing," that is, the stopping of current supply for a short period to allow the heat to distribute itself, when current is again applied and heating continued. Several applications of this "nursing" may sometimes be necessary.

(2) *Tubes.*—The slow butt method of welding tubes is generally used in making refrigerator coils and where the actual weld is to be completed by rolling between mandrel and rolls as is being done by some in the safe ending of boiler tubes. Welds of this character have no burr or projection on the inside of the tube. The general rule for clamping, heating, etc., is the same as in the welding of solid sections, except that the projection used is somewhat greater than would be used were it a solid section of same cross-sectional area. Also the amount of metal pushed up during final application of pressure is less than on solid sections, for, as stated above, the weld is completed by immediately placing tube upon a mandrel and rolling down this pushed-up metal, or upset, until its diameter is the same as that of the tube. On pipes or tubes, 2 in. or under in diameter, three lines of contact (with current carrying dies) approximately 120° apart is sufficient, but on all tubes over 2 in. in diameter, the dies should make contact over nearly the entire periphery, to insure even distribution of heat.

(3) *Irregular Shapes.*—Irregular shapes, such as angles, tees, channels, etc., are seldom welded by the slow butt method; rather, the flash method is used, which is described later.

(B) Non-ferrous Metal:

(1) *Solid Sections* (excepting thin flat strips).—Due to the fact that the period of plasticity on the temperature scale of copper, brass, aluminum, lead and zinc, is so short, the hand operated pressure butt welder is not so well adapted to the making of a slow butt weld as a welder having spring or weight pressure, the full amount of which is exerted throughout the entire heating and welding operation. The parts to be welded are clamped in dies, so as to give a projection about three times that used in welding a piece of steel of same cross-section, the full pressure to be used applied and the primary circuit closed. As soon as the abutting ends reach the welding or plastic stage, this spring or weight pressure forces them together, completing the weld, at the same time automatically breaking primary circuit. The above method is rarely used on parts having over 0.25 square inch, cross-sectional area, as the general use of this method is for the splicing of ends of coils of copper wire for winding purposes and the sizes rarely exceed this area. Due to the fact that the metal at the weld is softer than the original drawn wire, its strength cannot be as great. The welding of large sections (four or five square inches) of copper has never been successfully accomplished perhaps because the absence of any demand for same has not stimulated its development. Brass, however, gives better results than copper and quite strong welds can be obtained, but by the flash rather than the slow butt method. German silver also lends itself more readily to the flash method. Comparatively little has been done in the welding of aluminum, lead and zinc, but where no great strength is desired, they can be welded by the above slow butt method.

(2) *Tubes.*—The welding of tubes of copper, brass or aluminum has never been a success commercially, for while it is possible to make a weld that will not "leak," its strength is small. All welds are made by the flash method, the slow butt method seldom, if ever, being employed.

(3) *Thin Flat Strips.*—Here again the flash rather than the slow butt method is preferred and here again brass is the only one of the more common non-ferrous metals on which it is possible to obtain a weld having any great strength.

II. Welding of Two Pieces of Same Material but Different Cross Section

(A) Ferrous Metals:

(1) *Solid Cross-Section.*—(Rounds, squares, parallelograms where difference between altitude and length of base is not too great.)

The general welding procedure is the same as used in *welding of two pieces of same material and cross-section,* excepting that the tendency of the piece having the smaller cross-sectional area to heat the faster, is offset in one or more ways, as follows:

(a) By varying projection of parts, that is, by making the projection of part having larger sectional area somewhat longer than that of the smaller. This aids the distribution of heat in parts in one or more ways: First, by virtue of the fact the copper dies gripping the parts are good conductors of heat and therefore, making the projection on part which would normally heat the slower, of such a length that this loss of heat by conductance is reduced to a minimum, while increasing this loss in the smaller part by giving in a short projection even heating of ends may be obtained. Also, this varying of projections tends to equalize their electrical resistance. This equalizing of heating of parts by varying projections only, is employed only where the difference in cross sectional area is slight.

(b) By preheating larger section. When the difference in cross-sectional area is of any great amount, the tendency toward uneven heating is offset by preheating the end of part having the greater cross-sectional area. This may be done in the welder by means of what is known as a "bridge," which is a channel-shaped piece of copper, the two legs of which span the projecting end of smaller part and make contact only with copper dies gripping this part, while the outer or back face of channel makes contact with end of larger part; thus when the circuit is closed, the current flows through and heats this larger part only. When this larger part has reached

*Prepared largely by Mr. W. Remington, Chief Engineer, Thomson Electric Welding Co.

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a fairly high temperature, the "bridge" is removed the end of smaller part brought in contact with end of larger and weld completed in usual manner.

(c) By combining above two methods.

(d) Perhaps one of the most common methods employed in the welding of two pieces, having different cross-sectional area, is to turn down the projecting end of larger to give it the same area as that of smaller. It then becomes a weld of the first type.

(2) *Tubes, Irregular Sections, Thin Flat Strips.*—The welding of the above is seldom encountered, but the method followed would be the same as described under various subdivisions of (1) (Solid Cross Sections).

(B) Non-ferrous Metal:

The general welding procedure is the same as in *the welding of two pieces of same material and cross-section*, excepting that the tendency of the piece having the smaller cross-section to heat the faster, is offset in one or more ways as follows:

(a) By varying projection of parts, as described in (a) under Ferrous Metals.

(b) By turning down projecting end of larger part, as described in (d) under Ferrous Metals.

(c) By combining above two methods.

III. Welding of Two Pieces of Same Cross Section but Different Material

(A) Various Analyses of Ferrous Metals, One to Another:

(1) *Solid Cross Sections.*—(Round, squares, parallelograms where difference between altitude and length of base is not too great.)

The general welding procedure is the same as in *the welding of two pieces of the same material and cross-section* excepting that the tendency of one piece to heat faster than the other is offset in one or more ways as follows:

(a) By varying projection of parts, that is, by increasing the projection of part which would normally heat the slower, as described in (a) under *Welding of Two Pieces of Same Material, but Different Cross-Section.* This difference in projections will vary from very little where parts have similar thermal and electrical characteristics to a point where the ratio in length of projections is as 1 to 4, as in the welding of high speed steel to wrought iron, where no preheating is done.

(b) By preheating slower heating part, with bridge as described in (b) under *Welding of Two Pieces of Same Material, but Different Cross-Section.*

(c) By combination of above two methods. This latter is the more practical and universally used method.

(B) Various Analyses of Non-Ferrous Metals, One to Another:

The welding of non-ferrous metals, one to another, is rarely done by the slow butt method, rather the flash method is used.

(C) Non-ferrous Metals to Ferrous Metals:

Here again the flash rather than the slow butt method is used, excepting in the welding of very small parts, such as platinum wire tips on to spark plug stems, where an automatic welder, similar in action to the machine described above for welding of copper wire, etc., is used.

IV. Welding of Two Pieces of Different Cross Section and Material

(A) Various Analyses of Ferrous Metals, One to Another:

As described in (a) under *Welding of Two Pieces of Same Cross-Section, but Different Material.*

(B) Various Analyses of Non-Ferrous Metals, One to Another:

Here again the flash rather than the slow butt method is used.

(C) Non-ferrous Metals to Ferrous Metals:

Here also the flash rather than the slow butt method is used.

FLASH METHOD

I. Flash Welding of Two Pieces of Same Material and Cross Section

(A) Ferrous Metals:

(1) *Solid Sections, Tubes, Irregular Shapes.*—Parts to be welded are clamped in dies of welding machine giving equal or nearly equal projections to both parts, the primary circuit closed and the ends of parts brought together slowly. When these ends actually touch each other, they will "flash," that is, minute particles of molten metal will fly off; this flashing is continued until the entire faces of abutting ends have reached a welding heat when rapid and heavy pressure is applied, forcing ends together and completing weld, at the same time opening primary circuit. The above is, without doubt, the preferred method of welding, as the power and time consumption is considerably less and the personal equation of the operator enters to a much less degree than in any other type of weld, thus producing more uniform results. At the present time, some difficulty is encountered in flashing parts having cross-sectional areas of over 8 to 10 square inches, where the ratio of their cross-sectional dimensions is over 50 to 1, or less than 4 to 1, although by preheating parts in latter case, this difficulty is greatly minimized. There are two types of flash welds, the "cold flash" and the "preheated flash."

(a) *Cold Flash.*—By cold flash is meant that the parts to be welded are not preheated in any way. This cold flash is used where parts are of an area well within limits of designed capacity of welding machine.

(b) *Preheated Flash.*—By preheated flash it is meant that the parts to be welded are brought together in contact with each other before current is applied, as in the slow butt weld, the abutting ends allowed to reach a more or less high temperature, when the circuit is broken, the parts separated, the circuit again closed and completed as a flash weld of the first type. The preheated flash is used in welding parts having condensed sections of an area closely approaching the design capacity of welding machine and also where the physical or thermal characteristics of parts are widely divergent, as will be noted in several cases below.

(B) Non-ferrous Metals:

In welding of non-ferrous metals the cold flash is used entirely and is described under (A). The projection of parts should be two or three times as great as in the welding of low carbon steel.

II. Welding of Two Pieces of Same Material but Different Cross Section

(A) Ferrous Metals:

The general welding procedure is the same as in the *Flash Welding of Two Pieces of Same Material and Cross-Section* excepting that the tendency of the part having the greater cross-sectional area to heat more slowly is offset in one or more of the following ways:

(a) By varying projection, that is, by increasing projection of part having larger sectional area over that of the smaller for the same effects as given under *Welding of Two Pieces of Same Material, but Different Cross-Section* by the slow butt method. The varying of projections only is used where the difference in sectional area is slight.

(b) By preheating larger section. As described under Slow Butt Method.

(c) By varying the amount flashed off, that is, by flashing off an amount greater than would be, were the parts of the same area. This gives the heat a chance to equalize itself in the two parts.

(d) By combinations of above.

(B) Non-ferrous Metal:

As under (A) excepting that no preheating is used. The welding of parts having large sectional areas to parts having small areas, can be done only by preparing them such that the projection of the larger has approximately the same area as that of the smaller.

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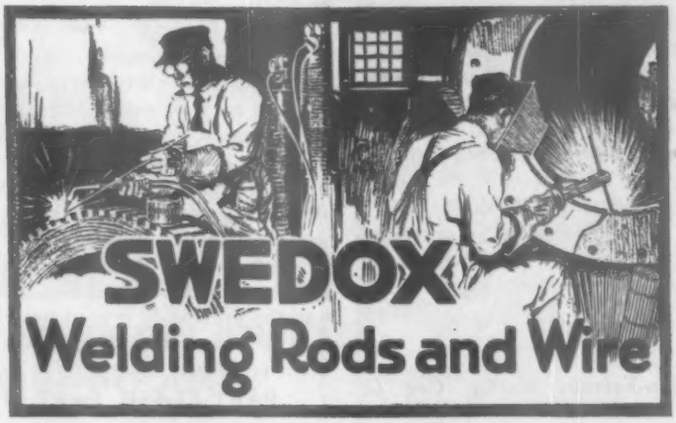

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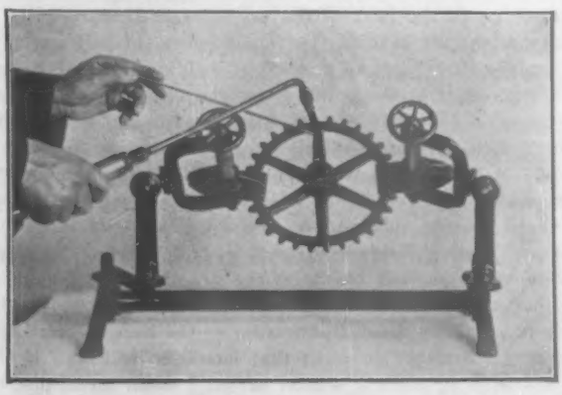

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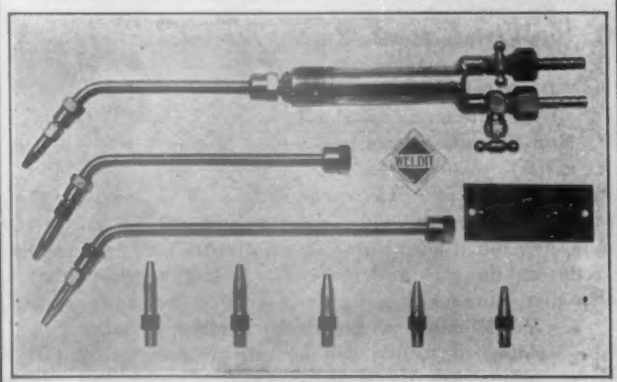

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III. Flash Welding of Two Pieces of Same Cross Section but Different Materials

(A) Various Analyses of Ferrous Metals, One to Another:

The general welding procedure is the same as in *Flash Welding of Two Pieces of the Same Material and Cross-Section* excepting that the tendency of one part to heat faster than the other is offset in one or more ways as follows:

(a) By varying projection, that is, by increasing the projection of the slower heating part over that of the other, where normal unit difference in heating time is slight.

(b) By preheating slower heating metal. As described under Slow Butt Method.

(c) By varying amount flashed off. As described in (c) under *Flash Welding of Two Pieces of Same Material, but Different Cross-Section.*

(d) Combinations of above.

(B) Various Analyses of Non-Ferrous Metals, One to Another:

As under (A) excepting that no preheating is used. Welds between copper and various analyses of bronze or brass have been obtained, which had tensile strengths very nearly as great as that of copper wire, annealed. Large sections (four and five inches) of non-ferrous metals have never been welded.

(C) Non-ferrous Metals to Ferrous Metals:

As under (A) excepting that no preheating is used. Welds between C. R. steel and brass, bronze or copper have been obtained which had tensile strengths very nearly as great as that of the metal to which the steel was welded. The welding of stellite to ferrous metals is described under separate heading.

IV. Flash Welding of Two Pieces of Different Cross Section and Material

The above is really a combination of the conditions met in the *Flash Welding of Two Pieces of Same Material, but Different Cross-Section* and the *Flash Welding of Two Pieces of Same Cross-Section, but Different Material* and would be welded by one or more of the following methods, all of which have been described above.

(A) Ferrous Metals, One to Another:

(a) By varying the projections.
(b) By preheating slower heating metal.
(c) By combinations of above.

(B) Non-Ferrous Metals, One to Another:

(a) By varying projections.
(b) By varying amount flashed off.
(c) By combination of above.

(C) Non-Ferrous Metals to Ferrous Metals:

As in (B).

In all above cases where the difference in cross-sectional areas is of any amount, say more than one and one-half or two to one, it is much better practice to prepare parts for welding by reducing the area and shape of the larger part to that of the smaller, thus making it a flash weld of the first type.

V. Welding of Stellite to Ferrous Metals

The welding of stellite can be satisfactorily accomplished only by the preheated flash method. This preheating may be done in one of the following two ways: The parts are clamped in dies so as to give a projection of steel from 6 to 8 times that of the stellite piece, the ends then brought together and mutually preheated by rapidly bringing them into contact with each other and then separating again, with welder circuit closed. This is continued until required portions of projections have reached a fairly bright heat, when the weld is then made as in an ordinary flash weld. The other method of preheating is to use a bridge (previously described) and preheat the steel part only. If this latter method, which is the better method, is used, the difference in projections of parts need not be as great as in the first method, in fact, this difference is of small importance.

VI. Angle Welding

By this is meant the welding of parts at any angle less than 180°, such as rectangular frames of angle iron, flat strip, various shapes of tubing, etc. The general cold flash method is used.

VII. Tee Welding

As the name implies, this is the welding of two parts at right angles to each other. Either the slow butt or the flash method may be used. In either case the head of tee should be preheated, either by bridge, or where parts are small or are to be flash welded, they may be mutually preheated by "nursing." Where the top of the tee is of a cross-section larger than the vertical part of the tee, it is sometimes necessary to use a welder so designed that the current at first flows only through the top of the tee, thus heating this piece. The current is then changed to flow from the vertical part of the tee into the previously heated top of the tee, bringing both pieces to a welding temperature and the weld is completed by the usual push-up.

PART FLASH, PART SLOW BUTT METHOD

This is when the weld is started as a cold flash and finished as a slow butt weld, as is particularly applicable to the welding of such parts as tubing, where the weld is to be completed by rolling between mandrel and rolls, as here the flash must be kept at a minimum, also in welding of hollow rock drill steels, where any great amount of flash would cause the hole to become clogged. By starting as a flash weld, the inequalities of the surfaces of ends of parts are burned off, so that when they are brought together for final heating preparatory to upsetting, the ends make good contact over entire area and thus insure even distribution of heat.

SUPPLEMENT

As a supplement to the foregoing, I would say that the successful completion of many welds is only brought about through specially designed dies or through specially forming the pieces to be welded. Dies may be cut out or relieved in certain places so as not to conduct the heat away from the welded part so rapidly as would otherwise have been the case. Also the cooling effect of the dies is many times utilized to prevent the heat running back too far or to prevent the overheating of the piece in a certain locality. This matter of properly fitting the dies is of much greater importance where the slow push-up method of welding is used than it is where the flash method of welding can be used, due to the fact that when the flash method of welding is used, the resistance of the arc is so great that the current distributes itself very evenly and also due to the fact that most of the heating effect is due to the heat of the arc instead of due to the resistance of the metal to the current flowing through it.

When the slow push-up method of welding is used, the heat will always start at the point where the two pieces first come together. This is many times a disadvantage and slows up the process, such as you can well imagine would be the fact in the case of two pieces of pipe being welded together or two round sections of rod being welded together where the contact came on one side and on the outer edge of either bar or pipe. To obviate this in the case of bars, many times, especially in years past, it has been the practice to point one or the other of the bars so that the contact will start at the center and thereby cause the heating of the bars to start from the center. Another practice that has been followed in this case has been to place a washer or solid small metal disc between the ends of the pieces and in this way, cause the heat to start from the center. In the case of pipes, it is sometimes the practice to bevel the edge of one of the pieces from both the inside and outside so as to cause the start of the heat at the center of the wall of the pipe. In the case of wires or bars, which have been sheared off, it has been the custom to place them in the dies so that the ridges left by the shears cross each other at right angles, and thereby cause the heating to start from the center. Later practice, however, has been to flash the parts for a second or two and thereby even up the surfaces before the parts are brought together and heated for the completed weld.

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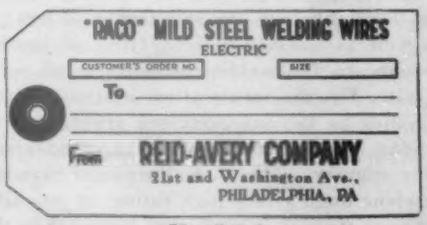

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There are many "tricks" or "stunts" used when welding two pieces of different form together, such as where a flat piece is welded into the end of a round pipe or a knife blade into the handle of a knife, or in the case of where two flat rectangular pieces are welded together with their longest cross-section dimension at right angles to each other. As these "tricks" or "stunts," however, are very great in number and as they apply generally to the individual case in question and cannot be applied generally, I believe that it would be useless to try to enumerate them. This is really the part of the art in which the service of the manufacturer is of the greatest value to his customers. It is the maintenance of this sort of service, which is largely responsibe for the apparent high cost of resistance welders. On the other hand, if it were not for this service, the employment of resistance welders in manufacturing would be very much smaller indeed than it is at the present time.

It would seem very desirable if cuts and descriptive matter of these various "stunts" could be collected and made available to users of welders, but the writer believes that this would not be practical, due to the fact that a very slight difference in voltage or pressure will many times prevent a successful weld, even when the dies and parts to be welded are properly formed. The manufacturer's case might be practically the same as the case described and illustrated and yet a very slight difference, which he might consider of no importance at all, would require such a difference in secondary voltage or pressure, as to make the description valueless to him. For this reason, the writer believes that the manufacturer of welders will always have to continue an experimental and service department for the benefit of his customers. Such a department, the manufacturer of the welders is constantly developing, so that what may seem impossible in welding today, may be very readily welded in sixty days to three months from this time.

OXY-ACETYLENE WELDING IN ELECTRIC RAILWAY SHOPS

(*Continued from page* 37)

also true of thermit welding, if I am correctly informed—I say, bearing these things in mind, one begins to realize the immense field that has been developed for welding by all of these processes of recent years in the electric railway industry.

I suppose some of you may have expected a particular reference to the welding of rail bonds. A great deal has been written on the subject. All manner of tests have been run with a view to establishing the superiority of one process or another, as well as tests of various types of bonds without special reference to the welding process employed. I wish merely to state, for the information of those present, that welding of bonds by the oxy-acetylene process is extensively employed today by large electric railway companies in every section of the country. The U. S. Bureau of Standards gives the oxy-acetylene bond a very high rating, as you all probably know and though its cost is somewhat higher than that of the electric welded bond, especially where current is charged against operations instead of being debited to upkeep, there are still master mechanics and construction engineers who believe that there are physical compensations which more than offset the difference.

Gentlemen, I whole-heartedly congratulate the welding fraternity, without reference to any particular process they may favor or represent, on the splendid progress each and all are making. Though the interests of individual processes at times come into conflict, their service to American industry is a common one and any real good the welding industry partakes of is, after all, only the fruit of benefit sown in the way of practical help to the users of welding processes. This view, I believe, is coming to be shared by the welding industry as a whole and I cannot but feel that it is this attitude, more than anything else, which is nourishing the confidence of American industry for welding today.

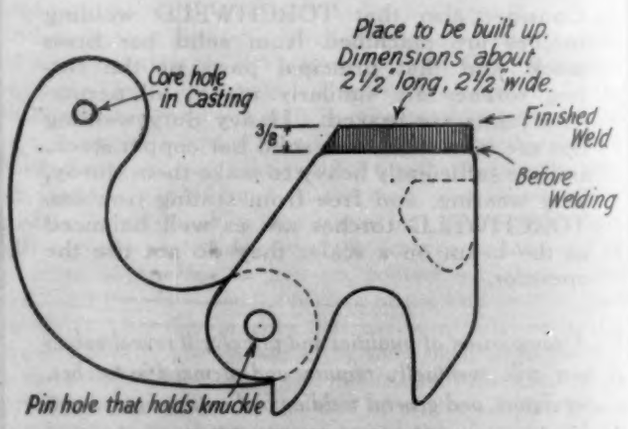
A NEW ELECTRIC ARC WELDER

The Klauer Manufacturing Company, Dubuque, Iowa, have recently announced the Klauer-Jaeger portable gasoline engine driven electric arc welding and cutting machine. The generator used in this plant has a rated capacity of 175 amperes normal, 200 amperes maximum, and is of standard design and construction. The gasoline engine is 10 h. p., water cooled, of standard make. The generator and engine are mounted on a substantial cast bed plate firmly bolted so as to keep all parts rigid and aligned. The machine is so designed as to easily engage and disengage the generator from the engine, making available a 10 h. p. gasoline engine in case it is needed for the operation of some other machinery. The generator will produce an arc of from 50 to 200 amperes. The illustration shows one of these outfits mounted on a truck, a method the manufacturers are taking to give their welding outfit publicity in their territory.

Klauer Arc Welder Mounted on Truck.

SAVING KNUCKLES

Although there seems to be no limit to the variety of jobs that can be accomplished by welding in the railroad shops, a railroad welder points out that not all shops are taking full advantage of the opportunities to salvage broken or worn out material. As an example of a typical salvage job, the building up of the knuckle of a locomotive or box car draw head is taken. These parts wear out very fast where they rub on the lock and soon get so that the inspector's gauge goes through the opening where they couple. It is often customary to scrap them and put in new knuckles. Since they are made of cast steel, they can easily be built up over the worn spots because it only takes ⅛ inch of new metal to put them back in first class shape. The accompanying sketch shows the points of greatest wear and indicates how simple a job it is to reclaim these pieces in the shop.



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To take over patents, working drawings and models of welding and cutting torches. Will sell entire set of patents, etc., for $500.00, or will arrange with manufacturer to produce them on a profit sharing basis. This is a splendid opportunity for a manufacturer whose line is not now complete. An interview can be arranged at Chicago or Milwaukee. Address 50, care The Welding Engineer.

Acetylene Cylinders Bought and Sold—I can save you money on the purchase of Prest-O-Lites and other acetylene cylinders or will help you if have any to dispose of. Robt. B. Dyar, 140 S. Dearborn St., Chicago, Ill. t.f.

Wanted—Prest-O-Lite tanks, motorcycle size. State lowest price and quantity. Address Alexander Milburn Company, 1418-26 W. Baltimore St., Baltimore Md.

Position Wanted—Electric and acetylene welder with supervisory experience wishes to connect with reliable firm in New York or vicinity. Address 48, care The Welding Engineer.

Position Wanted—Exceptional ability, best references. Lincoln process street railway joint welding and bonding. Thoroughly capable of superintending all street railway welding, bonding and grinding. U. S. Navy certificate as arc welder. Address 49, care The Welding Engineer.

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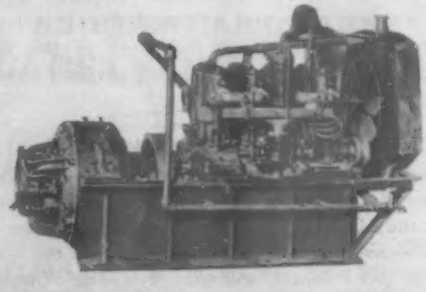

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W. A. SLACK PUTS IN A GOOD WORD FOR THE A. W. S.

In the September issue of "Chatter," the official organ of the Machinery Club of Chicago, W. A. Slack, president of the Torchweld Equipment Company, has written an article entitled "A Survey of the Oxy-Acetylene Industry," in which he points out the present status of the oxy-acetylene welding processes and the opportunities for using this process in such plants as the Machinery Club represents. The paper goes on to mention the organization of the American Welding Society, and to sketch briefly its recent activities in establishing new sections at important points in the United States. This is a good suggestion for all those in the welding industry who have occasion to make short talks before engineering bodies or to write articles for various technical papers, to give a little additional publicity to the American Welding Society, and thus get the public better acquainted with its activities.

C. A. M'CUNE ADDRESSES CLEVELAND SECTION

The first fall meeting of the Cleveland section of the American Welding Society was held October 12, in the rooms of the Cleveland Engineering Society, Hotel Winton. C. A. McCune, president of the American Welding Society, read a paper on the subject of "Welding Fundamentals."

The first fall meeting of the American Welding Society, Chicago Section, will be held in the rooms of the Western Society of Engineers, Monadnock Building, Dearborn and Van Buren Streets, Chicago, on Friday evening, November 3. A paper will be presented on the subject of "The Application of Oxy-Acetylene Welding." It is expected that meetings of the Chicago Section will be held on the first Friday of each month throughout the winter.

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Current Welding Literature

RESEARCH ON THE DIRECT ACTION OF ACETYLENE UPON COPPERS AND ITS ALLOYS—The story of the early experiments with the formation of acetylide and consequent regulations on the use of copper and its alloys in generators and fittings. It is noted that portable acetylene lamps constructed of brass have been used without accident, and it is concluded that the use of brass does not present the disadvantages which are due to the use of copper. Recent research work seemed to indicate that acetylene under pressure has no action on bronze, brass and red copper, and the acid has no effect on metal. It has been recommended that the regulations concerning copper should be maintained, and the use of brass restricted to that containing 70% of copper.—Acetylene & Welding Journal, London, September, 1922.

THE CARE OF OXY-ACETYLENE WELDING AND CUTTING EQUIPMENT, by H. Thompson—Cylinders are perfectly safe when handled with care, but become a menace when they are handled carelessly. Care must be taken to prevent over-heating of the generating chamber in water to carbide generators. In the case of the carbide to water type, sufficient water must be kept in the tank and the sludge tap at the bottom must not be allowed to get stopped up. The purifying material should be stirred up occasionally, so it will not become too badly packed. Regulators must be kept clean, the seats kept in good condition, and worn valves replaced by new ones when necessary. Explosions can be avoided by careful handling, and by keeping oil and grease away from the fittings. Oxy-acetylene equipment should be given the same care and attention as expensive machine tools.—Australian Automobile Trade Journal, August, 1922.

WELDING CAST IRON, by A. S. Kinsey—The influence of carbon, silicon, manganese, phosphorus and sulphur on iron castings. The physical nature of cast iron. Its expansion when heated. Its fluidity and its freezing point. The tendency of cast iron to harden when cooled rapidly. Suggestions for welding compound, soft and chilled iron castings.—Railway Mechanical Engineer, October, 1922.

CUTTING HEAVY COPPER BILLETS WITH THE ELECTRIC ARC, by A. M. Candy—Because of the great heat conductivity and thermal capacity of copper, tests were made to see if it could be raised by an arc to a sufficiently high temperature quickly enough to produce local fusion of the copper at the cut. These tests were continued on a large piece of copper slag having an average thickness of 4½ in. A 7 ft. cut was made in approximately two hours by an electric arc. For this work the generator was required to deliver a minimum of 1,000 amp.—Industrial Engineer, September, 1922.

HIGH SPEED WELDING OF SMALL PARTS, by E. H. Hubert —Description of the special electrodes and details of the procedure whereby 1,000 welds an hour are made in the manufacture of steel greased cups. A semi-automatic spot welding machine is used. The parts are assembled on a revolving dial. When an electrode is in place underneath the top electrode the dial stops and the weld is made. Each weld takes about 1½ seconds.—Industrial Engineer, September, 1922.

APPLICATION OF THE WELDING TORCH TO RAILROAD REPAIRS—A welding torch reduces the cost of making repairs. Locomotives can be put back in service without their being dismounted. The salvage of many small parts made possible. New pieces made by cutting instead of by forging.—American Machinist, September, 1922.

TESTS ON WELDING CYLINDERS, by E. A. Fessenden and L. J. Bradford—Four types of cylinders for handling ammonia were tested. This paper describes the method of conducting the tests, presents the data obtained, and discusses the results. The conclusion is that vessels having forge welded head are the least reliable, and that burned steel is often present in the weld. Also that the principal defects in the acetylene welds are the coarse granular structure and the occasional porous spots and pin holes that develop with high pressure and poor adhesion of the welding material to the original plate.—Acetylene Journal, October, 1922.

SAFE PRACTICES IN OXY-ACETYLENE WELDING, by H. S. Smith—Safety instructions covering the following points: Storage of carbide and gasses—installation of equipment—installation of piping—manifolding of cylinders—operation of equipment. Special attention is given to the importance of wearing goggles.—Acetylene Journal, October, 1922.

REACTIONS—The quarterly publication of the Metal & Thermit Corporation Publication, New York City. Devoted exclusively to the subject of thermit welding. Current issue contains complete details regarding the new type of thermit rail joints. A number of interesting thermit repairs are described.

JOURNAL OF THE AMERICAN WELDING SOCIETY—The August and September issues contain complete papers and discussions prepared for the fall meeting of the Society in Chicago as follows: President McCune's Address Before A. E. R. E. A.; American Bureau of Welding and Organized Research; Welded Rail Joints; Welding for the Maintenance of 1600 Street Railway Cars; The Use of Thermit Welding in Street Railway Shops; Oxy-Acetylene Welding in Street Railway Shops; Welding of Cast Iron; General Properties of Cast Iron; Arc Welding of Cast Iron; Oxy-Acetylene Welding of Cast Iron; Resistance Butt Welding; Welded Pipe Joints.

CATALOGUE NO. 4—The new 36-page catalogue of Smith Oxy-Acetylene and Oxy-Hydrogen Welding and Cutting Equipment, issued by Smith's Inventions, Inc., Minneapolis. Catalogue describes and illustrates a variety of generators, torches, preheaters, goggles, fluxes, connections, etc. It is bound with a heavy paper cover and printed on good substantial paper.

WELDING ALUMINUM BRONZE—A study of the problems encountered in welding this alloy, shows among other things that it is possible to get results by laying the adding material on a piece to be welded instead of using the welding rod in the usual manner. It was found that the finding of manganese is very unfavorable and in some cases makes good welding impossible. Further studies of this alloy are in progress.—Revue De La Soudure Autogene—September, 1922.

INTERNATIONAL ACETYLENE ASSOCIATION CONVENTION

The fall convention of the International Acetylene Association will be held in the Hotel Sherman, Chicago, October 25th, 26th and 27th. The opening session to be held on the morning of October 25th will consist of the president's address and reports from the committees. In the afternoon, there will be papers on oxy-acetylene subjects. A theater party is being arranged for the evening. The morning session of the 25th will consist of talks from prominent insurance and safety men. On Thursday afternoon the members will visit the plat of the Underwriters Laboratories, Inc. The Friday morning session will be devoted to oxy-acetylene subjects and the afternoon session to subjects of particular interest to the house lighting members. A dinner will be held at the Hotel Sherman that evening.

THE WELDING INDUSTRY IN CHINA

Bulletin No. 6 has just been received from the China Oxy-Acetylene Welding Works, Changhai, China. The current issue of this interesting little publication contains eight pages. Practically all of the information consists of suggestions for making a great variety of repairs. Particular emphasis is laid on the subjects of welding pipes and welding boilers. In regard to the latter subject, it is pointed out that work of this nature must be done by welders of at least three years' pressure welding experience.

NEW WELDING FIRM IN KANSAS CITY

The Liquid Steel Welding Corporation has recently been organized in Kansas City, Mo., by Anton Lucas, who was formerly connected with the Metal & Thermit Corporation of New York City. The name "Liquid Steel" has been adopted for the welding compounds which this company will use. It appears that the process is practically the same as the well known thermit welding process which is used extensively in the railroad shops and other places where a great quantity of heavy welding is done.

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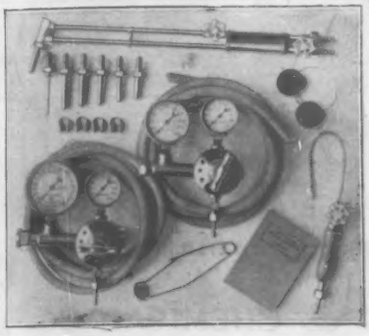

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1 Carbon Removing Torch	1.50	1 Length of 5-ply Acetylene Hose, 12½ ft.	1.50
1 Safety Torch Lighter	.50	4 Hose Clamps	.20
1 No. 30 Safety Front Oxygen Regulator with one 3,000-lb. Gauge, registering cu. ft. and one 300-lb. Gauge	24.00	1 Pair Welding Goggles	.50
1 No. 25 Acetylene Regulator, equipped with one 300-lb. Gauge and one 50-lb. Gauge	18.00	1 Instruction Book	1.00
		1 Adapter	1.50
		8 Cast Iron Rods, 1 Pound Cast Iron Flux; 8 Brass Rods, 1 Pound Brass Flux; 8 Aluminum Rods, 1 Pound Aluminum Flux; 10 Steel Rods	3.00
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3.00%—in Silicon (Result: A soft weld)
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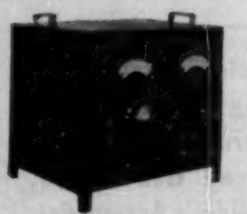

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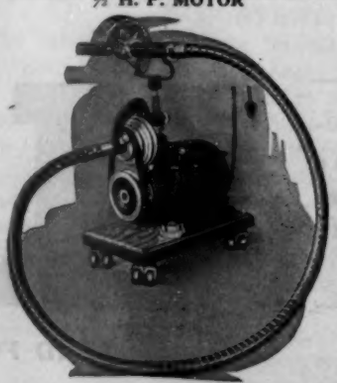

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Carbic

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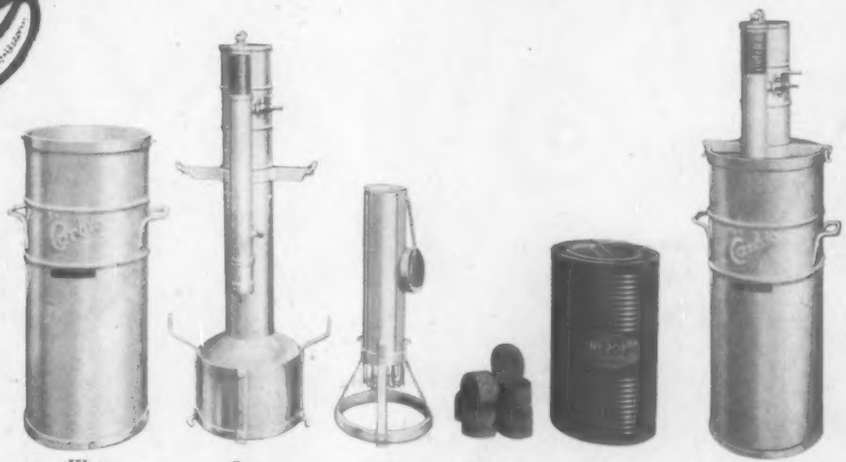

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Although of small size and light weight, this generator is substantially constructed throughout and has a gas producing capacity sufficient to make it thoroughly suitable for use on a wide range of work.

The Carbic generator is sold on its demonstrated merit and our sales policy provides all satisfactory guarantees.

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SPECIFICATIONS:

Height overall—52 inches.
Diameter—14 inches.
Weight empty—75 pounds.
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Shipping weight—boxed, 133 pounds.
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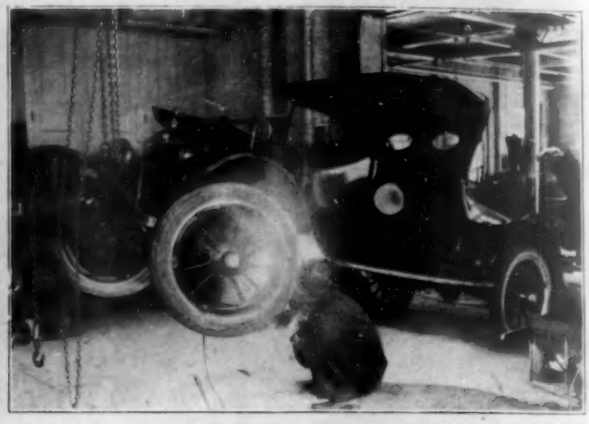

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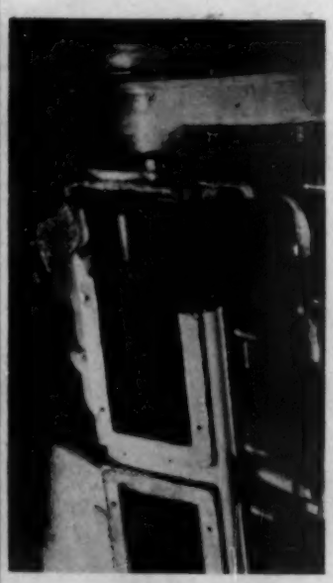
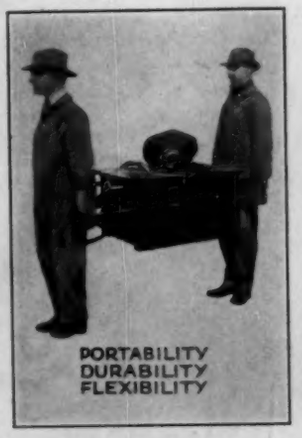


Reo Crank Case Welded



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